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An Analysis of Water Resistance and Propulsion in Swimming the Crawl Stroke

LOUIS E. ALLEY

State University of Iowa
Iowa City, Iowa

MOST OF THE studies of water resistance and propulsion in swimming may be classified with reference to procedure as belonging to one, or a combination of two or more, of the following general categories.

1. Studies in which the resistance offered to the body as it moves through the water is measured through a range of velocities by some type of towing mechanism. This resistance is commonly referred to as "drag" in the field of fluid mechanics, (12, *pp. 243–250*). The results obtained are used in conjunction with other measurements in an attempt to clarify the problem of water resistance and propulsion (4, 5, 8, 13).

2. Studies in which the propulsive force the swimmer can exert against a measuring device is used as a basis for attacking the problem of propulsion. The force measured in this manner is the propulsive force the swimmer can generate at zero velocity since the measuring mechanism prevents him from moving forward through the water (2, 3, 13).

3. Studies in which the maximum velocity the swimmer can attain is used as a primary measurement in arriving at conclusions relating to resistance and propulsion (1, 2, 4, 6, 10, 13, 14).

4. Studies that are primarily theoretical in nature in which formulas from classical hydromechanics are applied to the swimming movements or to the swimmer's performance (4, 7, 13).

Each of the above procedures, while not without considerable merit, possess certain inherent weaknesses which leave the conclusions from the results thus obtained open to serious question.

The drag obtained in the studies falling into category 1 above, while very useful as one method of approach to the problem, is not identical with the resistance offered to a swimmer propelling himself through the water by making certain movements with his arms and legs. A critical analysis shows the total resistance offered by the water to the forward progress of the swimmer in action to be not only a function of the velocity of the body relative to the water, but also to be a function of the velocity of each element of the arms and legs relative to the water. Thus, the nature of the swimmer's movements and the frequency of those movements has an effect upon the total resistance.

By the same reasoning, the propulsive force a swimmer can exert at zero velocity against a measuring device (category 2 above), is not the same as the propulsive force the swimmer can exert at any velocity other than zero. As an

illustrative analogy, a boy riding a coaster wagon and propelling himself by pushing with one foot is able to exert considerable force if the wagon is held stationary. He would, however, probably be "jerked" from the wagon if he were to attempt the same movement while the wagon was moving at a velocity of 30 miles per hour.

The use of the maximum velocity a swimmer can attain as a basis for attacking the problem, (category 3), has the practical value of determining which type of stroke is most effective from the standpoint of speed but offers little, if any, evidence as to *why* it is most effective for that purpose.

The rational methods employed in classical hydromechanics for the development of equations relating to fluid motion (category 3) require certain simplifying assumptions which often result in a wide divergence between mathematical solution and experimental results (11, *pp. 1-2*).

The most feasible approach to the problem of analyzing the resistive and propulsive forces in swimming appears to be some form of performance analysis. This method is quite common in the field of fluid mechanics and has proven to be quite fruitful in studies of drag (11, *pp. 211-212*), and in studies of airplane propellers and ship screws (12, *pp. 290-297*). The analysis must include the measurement of the propulsive force the swimmer can exert over a range of velocities in order to observe the changes in the resistance and the propulsive force with changes in velocity. Changes in resistance must, of necessity, be measured in terms of changes in the propulsive force. The factors of body size and shape of the swimmer must be controlled as must be the frequency of the swimming movements. Such was the purpose of this study.

Statement of the Problem

The purpose of the study was to investigate the problem of water resistance and propulsion in swimming the crawl stroke by means of a performance analysis method.

Definition and Discussion of Terms

This method of approach necessitated the formation and definition of several terms unique to the problem. Proposed terms and corresponding definitions are as follows:

(a) *An arm-stroke cycle*. An arm-stroke cycle is defined as the movement of the arm from entry into the water to entry into the water. Thus, one arm-stroke cycle consists of the stroking movements of the left arm plus the stroking movements of the right arm.

(b) *The arm-stroke frequency*. The arm-stroke frequency is defined as the number of arm-stroke cycles per second.

(c) *A kicking beat*. A kicking beat is defined as the movement of the leg and foot from maximum depth in the water to minimum depth in the water, or from minimum depth to maximum depth.

(d) *A kicking cycle*. A kicking cycle is defined as the number of kicking beats per arm-stroke cycle.

(e) *The kicking-cycle frequency.* The kicking-cycle frequency is defined as the number of kicking cycles per second.

(f) *Free velocity.* The free velocity is defined as the velocity a swimmer can maintain with a given arm-stroke and/or kicking-cycle frequency when he is not restrained by the apparatus.

(g) *Drag.* The drag is defined as the force required to tow a swimmer through the water at any given velocity while he is in a prone position, face down, with arms extended above the head and parallel, legs straight and together, toes extended, and the head held so that the water level is approximately across the bridge of the nose.

(h) *Towing force.* The towing force is defined as the force required to tow a swimmer *while he is kicking* at any given velocity greater than his free velocity for the corresponding kicking-cycle frequency. Except for the movement of the legs, the position of the body is the same as described in the definition of drag, (g) above.

(i) *Surplus-propulsive force.* The surplus-propulsive force is defined as the force a swimmer can exert at any given velocity over and above the force required to overcome the resistance offered by the water at that velocity. It may also be regarded as the force available for acceleration at any given velocity.

(j) *Effective-propulsive force.* The effective-propulsive force is defined as the surplus-propulsive force for any given velocity *plus* the drag for that same velocity. It is, thus, a *computed* measure of the total propulsive force a swimmer can exert at any given velocity.

(k) *The normal-arm stroke.* The normal-arm stroke is defined as an arm stroke in which the elbow is extended and the hand passes almost directly under the medial plane of the body throughout the major part of the pull through the water. When the arm has completed approximately 115° of its 180° pull, the elbow starts bending to allow the arm to be pulled from the water. It is the type of arm action normally used in swimming the crawl stroke.

The "timing", or co-ordination, of the arm-stroke cycle is defined as follows. Assuming the right arm to be above the surface of the water, the right hand enters the water when the left arm has completed approximately 90° of its 180° pull. The right arm moves through the water rather slowly, completing only 20° of its pull, while the left arm completes the remaining 90° of its 180° pull. It then accelerates rapidly and has completed 90° of its 180° pull by the time the left arm re-enters the water. The left arm pulls through 20° while the right arm is completing its pull and has pulled through 90° by the time the right arm re-enters the water.

(l) *The bent-arm stroke.* The bent-arm stroke is defined as an arm stroke in which the hand enters the water on a line with the shoulder, as in the normal-arm stroke, but the elbow is bent at approximately a 90° angle as the arm is pulled through the water. The forearm passes under the body, parallel to the surface of the water, the depth of the hand being determined by the length of the upper arm. The pull is completed by sweeping the hand back and out, the hand being lifted from the water at the hip as in the normal-arm stroke.

The "timing", or co-ordination, of the bent-arm stroke is the same as in the normal-arm stroke.

(m) *The normal kick.* The normal kick is defined as a flutter kick of approximately 12 inches as measured from the top of the instep of one foot to the back of the heel of the other at the instant of maximum spread. This was the kick normally used by the subject while competing in swimming events.

(n) *The short kick.* The short kick is defined as a flutter kick in which the distance of maximum spread is shortened to approximately 6 inches as measured from the instep of the upper foot to the heel of the lower foot.

Procedure

THE APPARATUS

A schematic diagram of the apparatus is shown in Figure I. The velocity of the swimmer was controlled by the power from a 1 horse-power, 2-phase, 60-cycle, 220-volt motor (A), which was rated at 1750 revolutions per minute. The

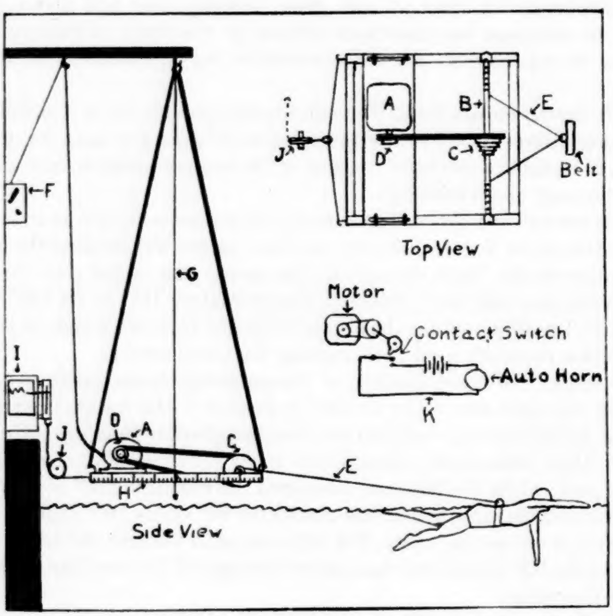

Fig. I. Apparatus for Controlling Velocity and for Measuring Drag, Towing Force and Surplus-Propulsive Force.

Key:
A Motor
B Shaft
C Shaft Pulleys
D Motor Pulleys
E Cord
F Reverse Switch
G Plumb Line
H Scale
I Kymograph
J Ball Bearing Pulley
K Pacing Device

power was transmitted from the motor to a steel shaft (B), by means of a V-belt. The shaft was ¾ inches in diameter and 48 inches long. A five-step pulley (C) was attached to the shaft and a two-step pulley (D) was attached to the armature of the motor. The revolutions of the shaft were varied by utilizing the various possible combinations of the pulley system. The motor was equipped with a reverse switch (F), so that the shaft could be turned in either direction.

A heavy cord (E), 120 feet in length, was attached to the ends of the steel shaft as shown in Figure I. It passed through a small steel ring which was fastened to a web belt worn by the swimmer. When the swimmer was towed toward the apparatus, the cord wound around the shaft toward the center of the shaft. When the swimmer swam away from the apparatus, the cord unwound from the center toward the ends of the shaft. This arrangement prevented the cord from winding upon itself and increasing the effective diameter of the shaft and, thus changing the rate of winding.

The motor and steel shaft were mounted upon a framework of wood and the entire apparatus was suspended by ropes from two, 2-inch by 4-inch planks which extended from the balcony above the pool. This allowed the apparatus to swing freely when force was applied to the cord which wound about the shaft. Two plumb lines (G) were hung from the supports and a scale (H) painted upon the framework of the apparatus in order that the degree of swing of the apparatus could be measured and proper corrections could be made. The entire apparatus was suspended eight inches above the surface of the water during the course of the experiment.

The force exerted by the swimmer upon the suspended apparatus was measured by means of a kymograph (I). A spring scale was mounted on a type 200 B Variac kymograph (manufactured by General Radio Company, Cambridge, Mass.), so that an electrically heated stylus which extended from the rider of the scale made a continuous mark upon waxed paper as it rolled past the point of the stylus at the rate of 26.34 inches per minute. The spring scale was connected to the suspended apparatus with a flexible chain which passed through a ballbearing pulley (*J*), to accommodate the necessary change in direction of the force. As the swimmer swam away from or was towed toward the apparatus, the kymograph made a continuous, visible record of the elongation and recoil pattern of the spring scale.

The fluctuating nature of the propulsive force resulting from the arm strokes made it necessary to find the arithmetic average of the kymograph readings. This was done by tracing each reading at least three times with a planimeter and computing the average of the measured areas. The resulting average area was converted into pounds by comparison with the area of a square which represented a known force of twenty-five pounds applied for a standard time represented by the base distance L_1 and reduced to one pound force units, by dividing this area A_1 by $25L_1$. The average force X for an area A_2 measured for a base distance L_2 is therefore given by the formula:

$$X(\text{in pounds}) = \frac{A_2 \cdot L_1 \cdot 25}{L_2 \cdot A_1}$$

Two calibrated spring scales were used to determine the area of the square representing the twenty-five pounds, one as a check on the other.

A frequency-regulating device (*K*) was constructed which consisted of an automobile horn attached to a storage battery. A 60-cycle, synchronous motor was geared to a contact switch through a system of pulleys in such a way that the horn gave a loud, clear honk every 1.21 seconds. The swimmer regulated the frequency of his arm strokes by making one complete arm cycle with each sounding of the horn. This was slightly under the frequency the subject used while competing in dash events. The frequency of the kick was regulated by the swimmer kicking six beats with each sounding of the horn.

Balsa-wood floats were used to support the swimmer's legs during some of the drag tows in the low velocity area. They were also used to support his arms during the kicking runs.

The swimming pool was 60-feet long and 30-feet wide, ranging in depth from 5 feet at the shallow end to 8 feet at the deep end. The course, 30 feet in length, was laid off by stretching a cord across the pool 10 feet from the deep end wall and another cord 30 feet from the initial cord in the direction of the shallow end. All runs were made on a line through the center of the pool.

The timing was done with a stop watch graduated to one, one-hundredth of a second.

THE SUBJECT

All data were obtained from the swimming efforts of one subject, an "All-American" member of the State University of Iowa swimming team. It was felt that time and effort would be better spent in securing rather extensive data from the efforts of one individual than in securing less extensive data from many individuals with the attendant introduction of the uncontrolled factors of size, body shape, body density and swimming skill. No attempt is made, or intended, to project the results of the data to describe the propulsive and resistive forces of swimming in general terms.

COLLECTION OF DATA

Data were recorded for each of the following items. In each case, five trials were made at each velocity and a mean of the five resulting measurements was computed.

1. Drag.
2. The normal-arm stroke.
3. The bent-arm stroke.
4. The normal kick.
5. The short kick.
6. The whole stroke, using the normal-arm stroke with the normal kick.
7. The whole stroke, using the normal-arm stroke with the short kick.
8. The whole stroke, using the bent-arm stroke with the normal kick.
9. The whole stroke, using the bent-arm stroke with the short kick.

The arm-stroke frequency and the kicking-cycle frequency for all data were .894. The kicking cycle was six beats per arm-stroke cycle for all data.

The surplus-propulsive force was measured over a range of velocities for the normal-arm stroke, the bent-arm stroke, the normal kick, the short kick, and the various combinations of the whole stroke. This was done by attaching the swimmer to the apparatus by means of the web belt and measuring the force he could exert at a given velocity as he swam away from the apparatus.

The towing force was measured for the normal kick and the short kick over a range of velocities which were greater than the free velocity for the corresponding type of kick. This was accomplished by measuring the force required to tow the swimmer toward the apparatus while he was kicking.

Drag was measured over a range of velocities by towing the swimmer toward the apparatus while he lay in the position described in the definition of drag. The results showed the effect of the feet sinking at the three lowest velocities so three additional readings were taken with the legs supported by balsa-wood floats.

The free velocity for the normal-arm stroke, the bent-arm stroke, the normal kick, the short kick, and the various combinations of the whole stroke was obtained by timing the swimmer as he swam the course using the method of propulsion in question.

The swimmer wore the web belt about his waist for the drag, normal kick, short kick and all combinations of the whole stroke trials. During the normal-arm stroke and bent-arm stroke trials the belt was worn about the ankles to prevent the legs from sinking.

During the free velocity trials for the normal-arm stroke and the bent-arm stroke, the balsa-wood floats were attached inside the lower legs to prevent them from sinking.

The swimming was done in a number of two-hour sessions over a period of several months. At the beginning of each session the probable amount of data which could be collected was decided upon and the trials were made in rotation with reference to strokes rather than five trials using the same stroke being made in succession. This was done in order that the fatigue of the swimmer might not influence the data for one type of stroke more than for another type. The swimmer was given ample time to rest between trials, the decision of when to start being left to his judgment concerning his ability to keep up with the horn. Since readings were discarded in all cases in which the subject was not able to stroke or kick in cadence with the horn, the effects of fatigue were considered to be negligible.

Analysis of Data

DRAG

The results of the drag measurements are shown in Figure V, in which pounds of drag are plotted against velocity in feet per second. The unbroken line is drawn as a curve of best fit through the means of the five trials at each of the various velocities for which data were taken. The broken line above and below the unbroken line is drawn through the maximum and minimum drag readings at each of the various velocities, as an indication of the range of the measure-

ments. The drag measurements plotted for the velocities 1.13, 1.46, and 2.08 feet per second were taken with the subject's legs supported by the balsa-wood floats. The remainder of the drag measurements plotted were taken with the subject's legs trailing without support. This plot of drag against velocity is also shown in Figure IV, and is used as the basis for computation for Figure VI and Figure VII. The widest range of drag measurements for any given velocity was 1.47 pounds.

Figure II shows a coefficient of drag plotted against velocity in feet per second. The readings at 1.13, 1.47, and 2.08 feet per second are plotted for the drag measured with the legs supported and also with the legs unsupported. All other readings shown are for measurements taken with the legs unsupported. The coefficient of drag shown was computed from the equation $D = C_1V^2$. Ordinarily the drag coefficient is computed from the equation $D = C_D\frac{dV^2}{2}A$, where d represents the density of the fluid, V the velocity, and A a characteristic projected area of the body upon which measurements are being taken. Since the subject was the same for all measurements and A and d were constant, they were omitted from the formula.

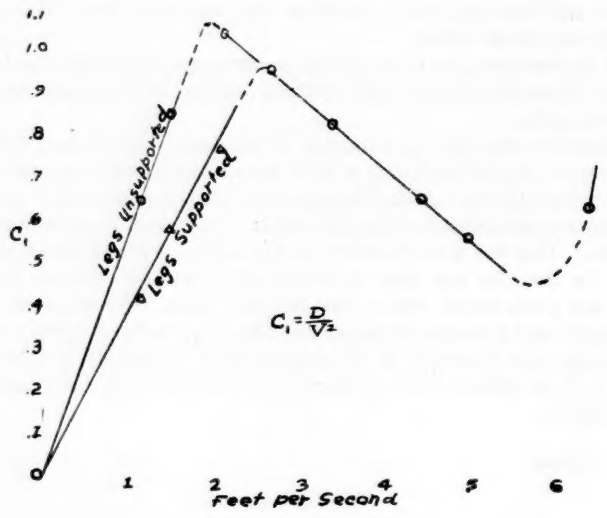

Fig. II. Coefficient of Drag.

When the legs were unsupported for velocities 0 to approximately 2 feet per second, they tended to sink and thus increased the resistance, as shown in Figure II. With the legs supported by the floats for these velocities, the drag rather

closely approximated a direct proportionality to the square of the velocity, the equation of the line of best fit for the points shown being $D = .698\ V^{2.095}$.

At velocities between 2 and 5 feet per second, a lift effect was observed. The legs were raised to the surface whether supported or unsupported. The use of floats at these velocities appeared to place the subject in an unnatural position for swimming, since they resulted in the legs rising too high in the water, so they were discarded for readings at velocities greater than 2.1 feet per second. The lift effect is indicated in the plot of C_1 by the decrease in C_1 between 2 and 5 feet per second. This decrease is probably due to the projected area and skin surface of the body exposed to the water becoming less as the body rises. There is a suggestion here of a possible relationship between body density and body resistance in water.

At some velocity between 5 and 6.4 feet per second, a noticeable bow wave of considerable magnitude was formed. It was noticeable but not prominent at the 5 feet-per-second velocity, but was very noticeable during the 6.4 feet-per-second velocity trials. It brought the water line up to approximately the hair-line of the subject and made breathing impossible without turning the head. Upon turning the head, the mouth was completely free of water, and air was available. The wave was of sufficient magnitude to produce a distinctly audible "slap" as it hit the side and end walls of the pool upon completion of the runs. The effect of the bow wave is indicated in the rise of C_1 for the 6.4 feet-per-second velocity measurement. The increased resistance in this area is probably an important factor in limiting the speed of competitive swimmers.

TYPES OF WHOLE STROKES

The results of the measurements for the various types of whole strokes are shown in Figure III in which the surplus-propulsive force is plotted for each of the velocities at which readings were taken.

The range in pounds of the measurements for the five trials using each type of stroke for each velocity is indicated below.

Approximate Velocity	NA-NK	NA-SK	BA-NK	BA-SK
0.0	7.27	3.07	4.21	2.28
1.1	5.21	1.96	.63	1.79
1.5	3.21	1.00	.30	1.26
2.1	2.30	1.88	1.17	1.11
2.6	1.76	1.86	1.26	2.35
3.4	1.91	1.75	1.75	1.58
4.4	1.45	1.41	1.23	—

The wide range in the measurements of the surplus-propulsive force for the whole stroke using the normal-arm stroke and the normal kick at the lower velocities was due, in part, to a "lunging effect" against the restraint of the apparatus causing it to oscillate more than it did with the other strokes.

The general pattern of decrease in surplus-propulsive force at the various velocities measured was similar for the four types of strokes, as indicated by the data in Figure III. In each case, there was a rather rapid decrease in force from

0 to 1.5 feet per second. From 1.5 to approximately 3.5 feet per second, the curve representing surplus-propulsive force tended to level off. Between the approximate velocities of 3.5 feet per second and 4.4 feet per second, the surplus-propulsive force began to decrease rather rapidly again and continued to decrease until the subject could supply only the force necessary to overcome the resistance of the water. This velocity is represented as zero pounds of force in Figure III.

While there is no statistical evidence available to show a significant difference between the means representing pounds of surplus-propulsive force at the various velocities, it is interesting to note the distinct separation of these means beyond the 2 feet-per-second velocity. Also, the means obtained for the whole stroke using the normal-arm stroke and the normal kick were greater than the means for the other types of strokes at each velocity at which the surplus-propulsive force was measured. The probability of this occurring by reason of chance alone must be rather small.

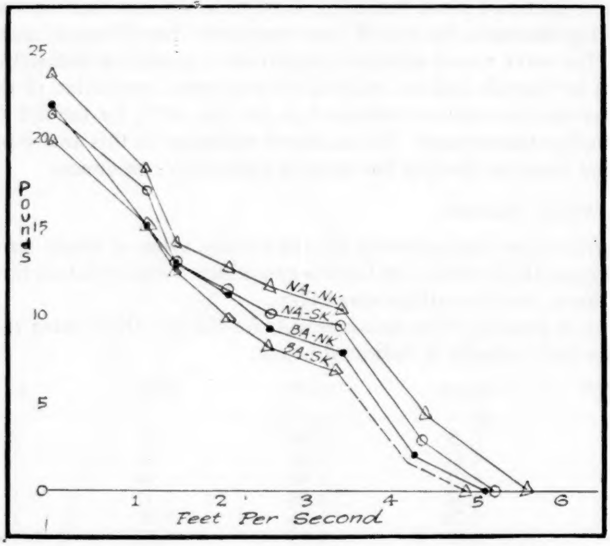

Fig. III. Surplus-Propulsive Force of the Four Types of Whole Strokes.
Key: NA-NK, The Whole Stroke using the Normal-Arm Stroke with the Normal Kick
NA-SK, The Whole Stroke using the Normal-Arm Stroke with the Short Kick
BA-NK, The Whole Stroke using the Bent-Arm Stroke with the Normal Kick
BA-SK, The Whole Stroke using the Bent-Arm Stroke with the Short Kick

THE NORMAL-ARM STROKE AND THE BENT-ARM STROKE

The results of the measurements of surplus-propulsive force for the normal-arm stroke and the bent-arm stroke are shown in Figure IV.

The range in pounds of the measurements of the five trials, using each type arm stroke, for each velocity is indicated below.

Approximate Velocity	Normal-Arm Stroke	Bent-Arm Stroke
0.0	3.71	3.75
1.2	2.61	2.64
1.5	3.13	1.99
2.1	2.53	1.07
2.6	1.60	.83
3.3	1.62	1.20

The surplus-propulsive force of both the bent-arm stroke and the normal-arm stroke declined rather rapidly and continued to decline until surplus force was no longer available, as shown in Figure IV. There is no indication in the data of the leveling off of this decline which was evident in the whole-stroke propulsion analysis.

At each velocity for which readings were recorded, the mean of the trials for the normal-arm stroke was higher than the mean of the trials for the bent-arm stroke.

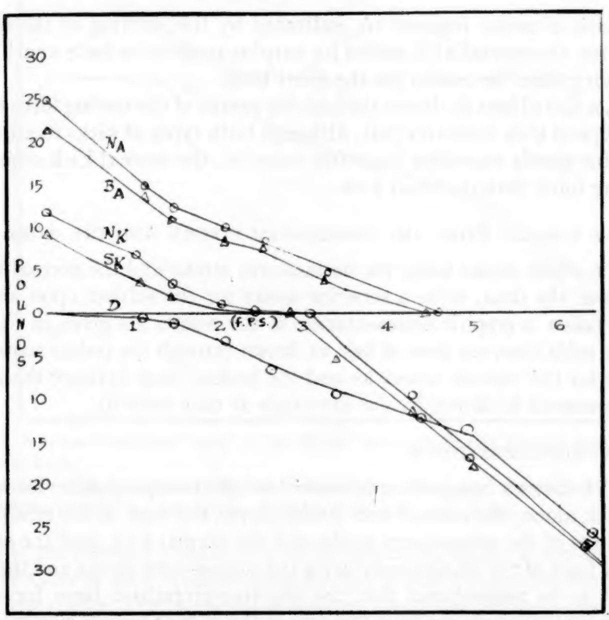

Fig. IV. Surplus-Propulsive Force of the Two Types of Arm Strokes and Surplus-Propulsive and Towing Force of the Two Types of Kicks.
Key: NA, Normal-Arm Stroke Alone; BA, Bent-Arm Stroke Alone; NK, Normal Kick Alone; SK, Short Kick Alone; D, Drag.

THE NORMAL KICK AND THE SHORT KICK

The results of the measurements of the surplus-propulsive force of the normal kick and the short kick are shown in Figure IV. The extension of the lines below the zero line show the results of the measurements of the towing force.

The range of the measurements of the surplus-propulsive force for the two types of kicks is shown below for each velocity at which it was measured. The towing-force range for each type is designated by a minus sign before the number of pounds.

Velocity	NK	SK
0	1.95	1.46
1.12	.76	.05
1.47	.89	1.06
2.01	.39	.51
2.45	0	Free Velocity
3.07	Free Velocity	—
3.40	—	−1.34
4.32	−2.36	−1.61
4.94	−1.99	− .72
6.33	−6.29	−3.39

Two items of major interest are indicated by the plotting of the measurements. First, the normal kick means for surplus-propulsive force were higher at each velocity than the means for the short kick.

Second, a line of best fit drawn through the means of the towing force required for each type of kick indicates that, although both types of kicks require a towing force for speeds exceeding their free velocity, the normal kick requires less of a towing force than the short kick.

THE WHOLE STROKE, USING THE NORMAL-ARM STROKE AND THE NORMAL KICK

Since the whole stroke using the normal-arm stroke and the normal kick appeared, from the data, to be a superior stroke for the subject upon whom the data were taken, a graphic representation of the results are given in Figure V. Again, the solid lines are lines of best fit drawn through the points representing the means for the various velocities and the broken lines indicate the range of the measurements as shown by the five trials at each velocity.

EFFECTIVE-PROPULSIVE FORCE

Figure VI shows a comparison between the effective-propulsive forces of the normal kick alone; the normal-arm stroke alone; the *sum* of the effective-propulsive forces of the normal-arm stroke and the normal kick; and the effective-propulsive force of the whole stroke using the normal-arm stroke and the normal kick. It is to be remembered that the effective-propulsive force for the arm stroke and for the whole stroke is the sum of the corresponding surplus-propulsive force and the drag. For the types of kicks, the effective-propulsive force is the sum of the surplus-propulsive force and the drag for velocities less than the free velocities of the kicks. For velocities greater than the free velocities of the kicks, the effective-propulsive force is the sum of the towing force and the drag,

the towing force being regarded as negative and the drag as positive. Data for Figure VI were derived from Figure V.

This method of analysis makes possible some illuminating observations. If the decrease in the surplus-propulsive force which accompanies an increase in velocity, as shown in Figure III, was due solely to drag, the effective-propulsive force would plot as a straight line with no slope. Figure VI shows clearly that more than pure drag is involved. As the velocity increases, the nature of the

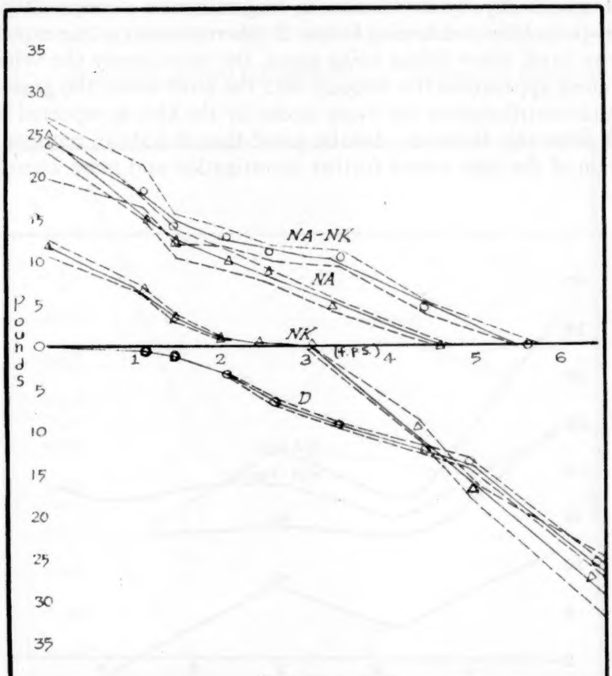

Fig. V. Surplus-Propulsive Force of the Whole Stroke using the Normal-Arm Stroke and the Normal Kick.
Key: NA-NK, Whole Stroke using the Normal-Arm Stroke and the Normal Kick; NA, Normal-Arm Stroke Alone; NK, Normal Kick Alone; D, Drag.

swimming movements results in a total resistance which is greater than the drag and there is an attendant decrease in the effectiveness of the propulsive force of the stroke. The increased resistance due to the nature of the swimming movements is relatively more pronounced in the case of the normal kick alone than in the normal-arm stroke alone.

The behavior of the effective-propulsive force at 0 velocity is interesting. The effective-propulsive force of the whole stroke using the normal-arm stroke and the normal kick is approximately the same as that for the normal-arm

stroke alone, indicating that the 11.7 pounds produced by the legs alone at that velocity have little effect upon the effective-propulsive force of the whole stroke.

There is an increase in the effective-propulsive force of the normal kick alone which begins, roughly, at a velocity of one and three-fourth feet per second and continues to a maximum at the free velocity. From this point, the effective-propulsive force decreases with an increase in velocity, becoming zero at the velocity where the drag and towing force are equal in magnitude. This increase is caused, graphically, by the increase in drag without a corresponding decrease in surplus-propulsive and towing forces. If this represents a true explanation of the case at hand, other things being equal, the more nearly the velocity with the legs alone approaches the velocity with the arms alone, the greater will be the amount contributed to the whole stroke by the kick as reported by Poulos (10) and Allen (1). However, definite proof that the above represents a true explanation of the case awaits further investigation and more accurate measurement.

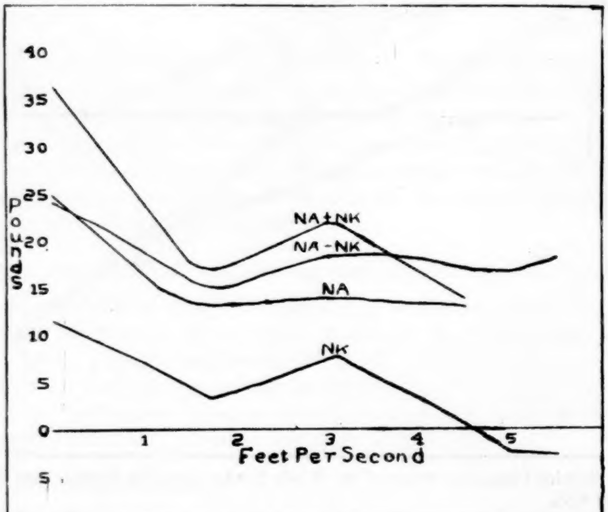

Fig. VI. Effective-Propulsive Force of the Whole Stroke using the Normal-Arm Stroke and the Normal Kick.

Key: NA-NK, Whole Stroke using the Normal-Arm Stroke and the Normal Kick; NA, Normal-Arm Stroke Alone; NK, Normal Kick Alone; Na+NK, Normal-Arm Stroke Alone *plus* Normal-Kick Alone

It is interesting to note that this increase in the effective-propulsive force of the normal kick alone is also reflected in the effective-propulsive force of the whole stroke and that no corresponding increase is present in the effective-propulsive force of the normal-arm stroke alone.

Figure VI also shows clearly that the force of the normal-arm stroke alone plus the force of the normal kick alone is not the equivalent of the force exerted by combining the two into the whole stroke, over the range of velocities. At a velocity of 3.7 feet per second the two quantities are equivalent but no particular significance can be attached to this point. There is no obvious relationship between the two quantities, as shown by the data, which will explain the ability of the swimmer to maintain a velocity with the whole stroke which is greater than the velocity he can maintain with the arms alone.

Figure VII shows a dimensionless performance curve for the normal-arm-normal-kick combinations. A coefficient of thrust, obtained from the equation $C_T = \frac{T}{1.94n^2L^4}$ is plotted against the ratio $\frac{V}{nL}$. T represents thrust in pounds,

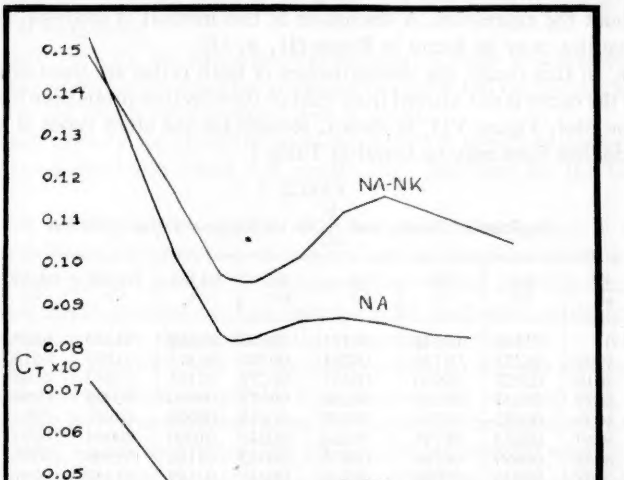

Fig. VII. Dimensionless Performance Characteristics of the Whole Stroke using the Normal-Arm Stroke with the Normal Kick.
Key: NA-NK, The Whole Stroke using the Normal-Arm Stroke with the Normal Kick; NA, Normal-Arm Stroke Alone; NK, Normal Kick Alone

n represents frequency of stroke in strokes per second, L represents the height of the swimmer in feet, V represents the velocity of the swimmer relative to the water, and 1.94 is the density of water in slugs per cubic foot. This method of dimensionless performance analysis is used in evaluating performance characteristics of airplane propellors as described by Rouse (12, *p. 292*). This expression of the performance of this subject is in dimensionless form, i.e., the expression $\frac{T}{1.94\ n^2L^4}$ and $\frac{V}{nL}$ are significant parametric groups which are purely numerical in nature. This allows the results of the study to be compared with the results of other studies even though the subject, the frequency of stroke, or the density of the water (salt or fresh) may differ, if one assumes the subject to be typical with relation to body proportion. The expressions are also independent of the system of measurement used providing the units of measurement are consistent throughout the expression. A discussion of this method of analysis, as applied in hydraulics, may be found in Rouse (11, *p. 13*).

Since, in this study, the denominators of both ratios are constants and the form of the curve is not altered from that of the effective-propulsive force curve, only one plot, Figure VII, is shown. Results for the other types of strokes in dimensionless form may be found in Table 1.

TABLE 1

Coefficient of Thrusts and $\frac{V}{nL}$ *for the Various Types of Strokes*

V	$\frac{V}{nL}$	NA C_T	BA C_T	NK C_T	SK C_T	NA-NK C_T	NA-SK C_T	BA-NK C_T	BA-SK C_T
0.0	0.0	.01526	.01341	.00171	.00562	.01489	.01359	.01292	.01223
.5	.1009	.01273	.01124	.00581	.00392	.01315	.01192	.01180	.01087
1.0	.2019	.01013	.00920	.00457	.00272	.01161	.01032	.01001	.00933
1.5	.3029	.00834	.00735	.00266	.00173	.00970	.00908	.00865	.00809
2.0	.4039	.00822	.00723	.00247	.00216	.00956	.00877	.00877	.00803
2.5	.5049	.00853	.00791	.00364	.00346	.01050	.00964	.00927	.00871
3.0	.6058	.00859	.00766	.00476	.00383	.01118	.01069	.00982	.00933
3.5	.7068	.00846	.00760	.00346	.00247	.01149	.01130	.01013	.00951
4.0	.8078	.00822	.00766	.00185	.00099	.01106	.01013	.00939	.00908
4.5	.9087	.00815	.00791	.00049	−.00037	.01075	.00907	.00908	.00877
5.0	1.0097			−.00124	−.00192	.01038	.00920	.00896	
5.5	1.1107			−.00130	−.00204	.01130			
6.0	1.2116			−.00154	−.00192				

$C_T = \frac{T}{1.94n^2L^4}$.

Summary and Conclusions

A towing device was constructed which controlled the velocity of the attached swimmer and, at the same time, recorded the force exerted by the swimmer upon the device.

The surplus-propulsive force exerted by a varsity swimmer in swimming the normal-arm stroke, the bent-arm stroke, the normal kick, the short kick, the whole stroke using the normal-arm stroke and the normal kick, the whole stroke using the normal-arm stroke and the short kick, the whole stroke using the bent-

arm stroke and the normal kick, and the whole stroke using the bent-arm stroke and the short kick was measured for nine different velocities, within the limits of the speed of the stroke. The frequencies of the strokes and kicks were controlled by a horn sounding device.

The drag of the subject was measured for each of the velocities.

Five trials were taken for each type of stroke and for the drag measurements at each velocity and means for each set of five trials were computed. Lines of best fit were drawn through the means and used as a basis for an analysis of the effective-propulsive force of the various types of strokes and kicks.

The data so obtained were the basis for the following observations.

1. A bow wave of comparatively small magnitude was observed at the 5 feet-per-second velocity during the drag measurements. At the 6.4 feet-per-second velocity the wave had increased to the extent that it very materially increased the drag. This bow wave is, probably, an important factor in limiting the speed of swimming.

2. At each velocity for which surplus-propulsive force was measured, the mean for the whole stroke using the normal-arm stroke and the normal kick was greater than the means for the other types of strokes.

3. At each velocity for which the surplus-propulsive force was measured, the mean for the normal-arm stroke was greater than the mean for the bent-arm stroke.

4. As the velocity becomes greater than zero, there is a decrease in the surplus-propulsive force of the whole strokes and arm strokes alone which is greater than can be attributed to drag. This decrease is no doubt due to a decrease in the effectiveness of the stroke and an increase in the total water resistance, both of which are caused by the nature of the swimming movements.

5. At each velocity for which the surplus-propulsive force was measured, the mean for the normal kick was greater than the mean for the short kick.

6. A towing force was required to tow the subject in the direction of his propulsive force at a velocity greater than his free-kicking velocity whether he was kicking the short kick or the normal kick. For velocities less than 4.3 feet per second and greater than the subject's free-kicking velocity, it required less towing force to tow the subject using the normal kick than it did to tow him using the short kick. At velocities greater than 4.3 feet per second, the data indicated no difference in the towing force for either kick. The range of the measurements for the normal kick at 6.4 feet-per-second velocity was too great to attach any significance to the mean for that velocity.

7. The data showed an apparent increase in the effective-propulsive force of both the normal kick and the short kick between the 2 and 3 feet-per-second velocities. This apparent increase was due to an increase in the drag with no corresponding decrease in the surplus-propulsive force of the kicks. This increase in effective-propulsive force was apparently reflected in the various types of whole strokes.

8. The surplus-propulsive force of the legs alone did not add materially to that of the arms alone when combined in the whole stroke at zero velocity.

9. The sum of the effective-propulsive force of the arm stroke alone and of the kick alone was not the equivalent of the effective-propulsive force of the corresponding whole stroke. The greatest difference between the two quantities was found at zero velocity. No explanation was apparent which would satisfactorily account for the magnitude of the differences at the various velocities.

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The Relationship of Body Size and Shape to Physical Performance

KARL W. BOOKWALTER

assisted by

HAROLD G. BAER
TOMMY BULLOCK
WILLIAM J. HIXON
VIRGINIA L. HOFFMAN
KENNETH E. KINION
ANTHONY J. MACARLE
DAVID RAINS
ERNEST RANGAZAS
MERLE ROUSEY
OTTO E. RYSER
WILLIAM H. SOLLEY
GERHARDUS VAN DER MERWE

Indiana University
Bloomington, Indiana

THE PURPOSE of this study is to show the relationship of physique and developmental level, as determined by the Wetzel Grid,[1] and the Indiana State Physical Fitness Test[2] scores of 1,977 Indiana elementary school boys.

Physique and developmental level are found in one plotting on the grid. The vertical axis on the left margin of the grid is calibrated for weight in pounds, and the horizontal axis at the top and bottom of the grid is scaled for height in inches. Thus to determine the physique and developmental level for any given individual, a measure of his height and weight is made, these values are found on the appropriate Grid scales, and lines are extended on the Grid until they meet. This point of meeting may be readily interpreted as to the channel (physique) and developmental level (size) of the individual being measured.

The grid is made up of physique channels, running somewhat vertically, and developmental levels, running more or less horizontally. After plotting a given height and weight on the grid, the point reached will fall within a channel and a developmental level. The three center channels, A_1, M, and B_1, represent boys of medium build. The channels A_2 and A_3 to the left of the three center channels represent boys having a stocky physique, and channels A_4 and up represent obese boys. Reading to the right of the center channels and down, channels B_2, B_3 and B_4 indicate increasing slenderness.

The diagonal scale at the extreme left of the physique channels indicates the boy's level of development or a measure of the boy's body size. Each level represents one month of growth and a certain value of body surface, regardless of the individual's physique channel.

The Indiana Physical Fitness Test for the Elementary Level is composed of four test items, straddle-chins, push-ups, squat thrust, and vertical jump. This

[1] Norman C. Wetzel, *Instruction Manual in the Use of the Grid for Evaluating Physical Fitness*, NEA Service, Cleveland, Ohio, 1941.

[2] C. C. Franklin and N. G. Lehsten, Indiana Physical Fitness Test for the Elementary Level, *The Physical Educator*, V, 3 (May 1948).

test, like the grid, is economical in terms of time, energy, and cost. Norms for the Indiana Physical Fitness Test have been established for Classification Index Groupings.

The specific purposes of the present study were to determine whether or not it is practical to classify students by the Wetzel Grid for performance on physical fitness tests and if so to establish norms for such a classification.

Procedure

The heights and weights were taken from the data cards used in standardizing the Indiana Physical Fitness Test, and the physique and developmental level of each boy were determined by plotting this information on the Wetzel Grid. Since the physical fitness scores had previously been computed, the three basic measures, physique, developmental level, and physical fitness as measured by the Indiana State test, were available for comparisons.

The data were studied from the standpoints of the distribution of boys by physique, the distribution of boys according to developmental level, physical fitness scores by physique groups, physical fitness scores by developmental levels, and physical fitness scores by combined grouping of physiques and developmental levels.

Throughout the study, developmental levels were combined into intervals of ten or more in order to facilitate manipulations of the data. Previous studies[3] showed finer groupings to be untenable for the present purpose. Physiques were studied from the standpoint of individual channels and from groupings of channels into more general body types, depending on the factor being studied.

Analysis of the Data

DISTRIBUTION BY PHYSIQUE CHANNELS AND DEVELOPMENTAL LEVELS

Of the total number of elementary school boys studied, 60.04 per cent fell within the three center channels, A_1, M, and B_1. Wetzel classifies these individuals as having good physiques. Stocky boys, channels A_2 and A_3, comprised 8.05 per cent of the total, while the obese and very obese individuals were 5.51 per cent of all boys studied. Of the total, 18.09 per cent had fair physiques (B_2), and 8.16 per cent were classified as borderline or poor, channels B_3 to B_6.

Wetzel has indicated that all children in channels outside the interval A_3 to B_2 are in need of medical observation or treatment.[4] Of the 1,977 subjects in this study, 31.86 per cent fall beyond this interval.

The developmental levels range from 50 to 200. The modal developmental level interval was 110–119, in which 17.06 per cent of the cases were found. Above this interval were 45.49 per cent of the boys; below this interval were 36.39 per cent of the total. The greatest concentration of cases was between the

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[3] Merle Arthur Rousey, *The Physical Performance of Secondary School Boys Classified By the Grid Technique*, Doctoral dissertation, Indiana University, Bloomington, Indiana, 1949.

[4] Norman C. Wetzel, Physical fitness in Terms of Physique, Development and Basal Metabolism, *The Journal of the American Medical Association*, **116**:1187–1195 (March 22, 1941).

Scale Scores for Indiana State Physical Fitness Test

	Wetzel Groupings						
Scale Score	A_3Up 150–200	A_2–B_6 150–200	A_3Up 100–150	A_2–B_2 100–150	B_3–B_6 100–150	A_2–B_6 50–100	Scale Score
100	148	168	85	137	149	133	100
99	146	166	84	135	147	131	99
98	144	164	82	134	146	129	98
97	143	162	81	132	144	128	97
96	141	160	80	130	142	126	96
95	139	159	79	129	141	125	95
94	137	157	78	127	139	123	94
93	135	155	77	126	137	121	93
92	133	153	76	124	136	120	92
91	131	151	75	123	134	118	91
90	130	149	74	121	132	117	90
89	128	148	73	119	131	115	89
88	126	146	72	118	129	113	88
87	124	144	71	116	127	112	87
86	122	142	70	115	126	110	86
85	120	140	69	113	124	108	85
84	118	139	68	112	122	107	84
83	116	137	67	110	121	105	83
82	115	135	66	108	119	104	82
81	113	133	65	107	117	102	81
80	111	131	64	105	116	100	80
79	109	129	63	104	114	99	79
78	107	128	62	102	112	97	78
77	105	126	61	100	111	96	77
76	103	124	60	99	109	94	76
75	101	122	59	97	107	92	75
74	100	120	58	96	105	91	74
73	98	119	57	94	104	89	73
72	96	117	56	93	102	87	72
71	94	115	55	91	100	86	71
70	92	113	54	89	99	84	70
69	90	111	53	88	97	83	69
68	88	109	52	86	95	81	68
67	86	108	51	85	94	79	67
66	85	106	50	83	92	78	66
65	83	104	49	82	90	76	65
64	81	102	48	80	89	75	64
63	79	100	47	78	87	73	63
62	77	99	46	77	85	71	62
61	75	97	45	75	84	70	61
60	73	95	44	74	82	68	60
59	71	93	43	72	80	67	59
58	70	91	42	71	79	65	58
57	68	89	41	69	77	63	57
56	66	88	40	67	75	62	56
55	64	86	39	66	74	60	55
54	62	84	38	64	72	58	54
53	60	82	37	63	70	57	53
52	58	80	36	61	69	55	52
51	56	79	35	59	67	54	51
50	55	77	34	58	65	52	50
49	53	75	33	56	63	50	49
48	51	73	32	55	62	49	48
47	49	71	31	53	60	47	47
46	47	69	30	52	58	46	46

Scale Scores for Indiana State Physical Fitness Test (*Continued*)

Scale Score	Wetzel Groupings A$_3$Up 150–200	A$_2$–B$_6$ 150–200	A$_3$Up 100–150	A$_2$–B$_2$ 100–150	B$_3$–B$_6$ 100–150	A$_2$–B$_6$ 50–100	Scale Score
45	45	68	29	50	57	44	45
44	43	66	28	48	55	42	44
43	42	64	27	47	53	41	43
42	40	62	26	45	52	39	42
41	38	60	25	44	50	37	41
40	36	59	24	42	48	36	40
39	34	57	23	41	47	34	39
38	32	55	22	39	45	33	38
37	30	53	21	37	43	31	37
36	28	51	20	36	42	29	36
35	27	49	19	34	40	28	35
34	25	48	18	33	38	26	34
33	23	46	17	31	37	25	33
32	21	44	16	30	35	23	32
31	19	42	15	28	33	21	31
30	17	40	14	26	32	20	30
29	15	39	13	25	30	18	29
28	13	37	12	23	28	16	28
27	12	35	10	22	27	15	27
26	10	33	9	20	25	13	26
25	8	31	8	18	23	12	25
24	6	29	7	17	21	10	24
23	4	28	6	15	20	8	23
22	2	26	5	14	18	7	22
21		24	4	12	16	5	21
20		22	3	11	15	4	20
19		20	2	9	13	2	19
18		19	1	7	11		18
17		17		6	10		17
16		15		4	8		16
15		13		3	6		15
14		11		1	5		14
13		9			3		13
12		8			1		12
11		6					11
10		4					10
9		2					9
8							8
7							7
6							6
5							5
4							4
3							3
2							2
1							1

developmental levels of 90 to 140, in which 70.14 per cent of the cases were found.

PHYSIQUE AND PHYSICAL FITNESS SCORES

The mean physical fitness scores by physique channels (See Figure I) indicate a general tendency for the fatter boys, channels A_3 and up, to make consistently

lower scores than boys with other physical builds. The boys in the middle five channels, A_2 to B_2, had approximately equal physical fitness scores, while the thinner boys, channels B_3 and downward, made slightly lower scores. The greatest deviation from the general mean of all physical fitness scores was found in the obese group, with the thin boys making considerably higher scores than the fat boys and only slightly lower than the average boys.

DEVELOPMENTAL LEVEL AND PHYSICAL FITNESS SCORES

Physique evaluates an individual's build, i.e., the shape of the body, as it relates to the build or shape of other individuals. It does not take into account

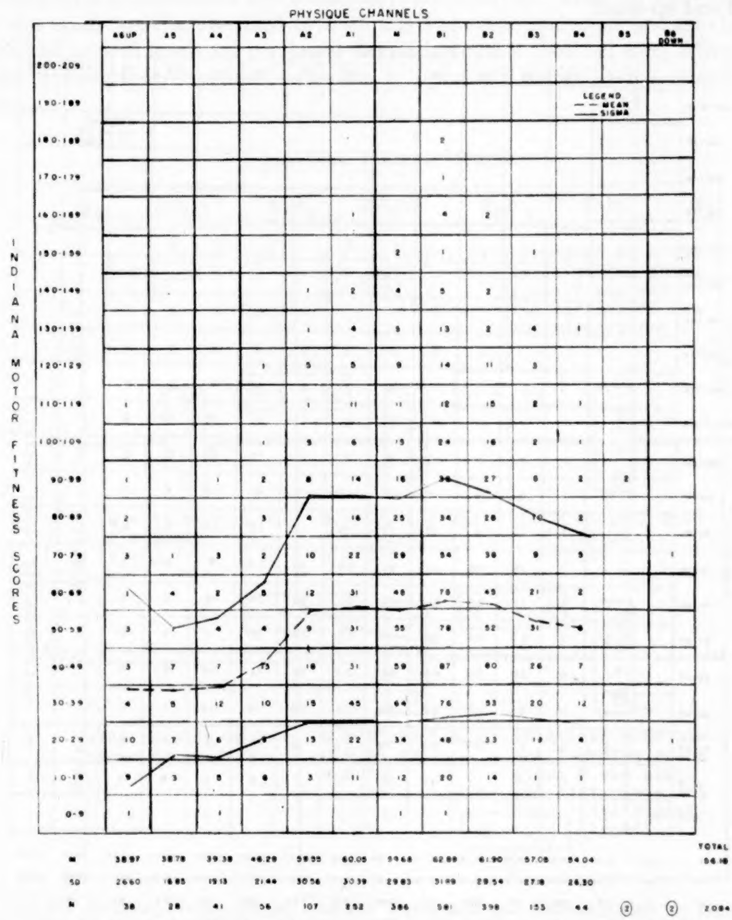

Fig. I. Fitness Scores for Indiana Elementary Boys by Physique.

the comparable size of the body. It was deemed important that some measure of total body size be made, and since the developmental level as determined on the Wetzel Grid is a measure of total body surface, this measure was used to determine the relationship between the degree of development and performance on the Indiana State Physical Fitness Test.

Figure II shows the means and standard deviations of the physical fitness scores of the elementary school boys according to developmental levels. Evidently a comparatively high relationship exists between developmental level and physical fitness as measured by the test given. There is a consistent increase in physical fitness scores as the developmental level increases up to 170; then scores decrease rapidly for the very large individuals with levels of 170 and up-ward.

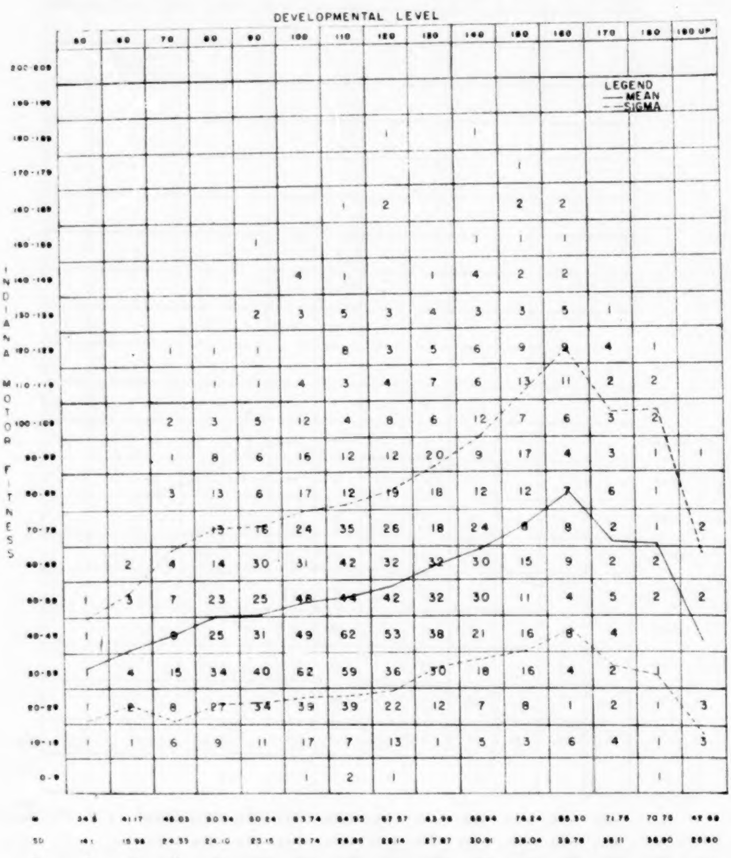

Fig. II. Fitness Scores for Indiana Elementary Boys by Developmental Level.

With the exception of the lower two intervals and the upper interval the variability of the physical fitness scores by developmental level intervals was somewhat equal in all instances, although a slight and progressive increase in the size of the standard deviation was found as the developmental level increased from the 80–90 interval to the 160–170 interval.

COMBINED GROUPING OF DEVELOPMENTAL LEVEL AND PHYSIQUE, AND PHYSICAL FITNESS SCORES

It has been found from previous studies that the most significant differences in physical performance are evident when the physique channel and the developmental level are combined into a composite classification. When the individuals in this study are characterized by both size and shape and when several channels and several levels are combined the critical ratios obtained from adjacent cells in physical fitness scores, as shown in Figure III, justify such a classification.

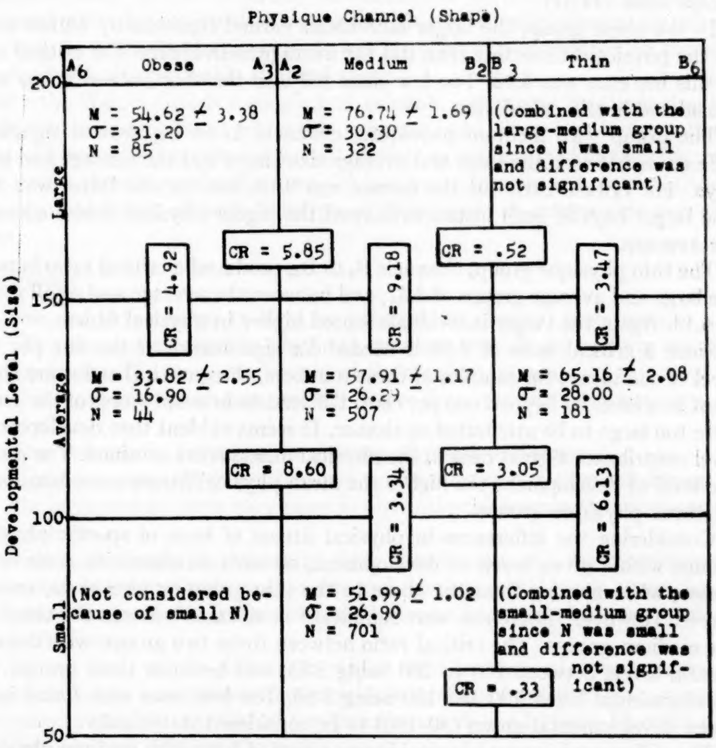

Fig. III. Physical Fitness Means, Standard Deviations, and Critical Ratios for Indiana Elementary School Boys of Particular Physiques and Developmental Levels, 1947.

To determine the significance of differences between physical fitness ratings of students of a particular physique and development, the total range of physique channels was divided into three parts, channels B_6 to B_3, B_2 to A_2, and A_3 to A_6, and the developmental level range was divided from 50 to 100, 100 to 150, and 150 to 200. Then all subjects were placed in the appropriate cells formed by these divisions, the mean and standard deviations were found for each cell, and critical ratios computed for all adjacent cells.

The highest mean fitness score, 77.78, was made by the largest boys (developmental levels 150 and above) in all physique channels. The obese boys (A_3 and up) in all developmental levels 100 and 150, have a mean fitness score of 59.77. The boys who are very thin (physique channels B_3 and lower) in all developmental levels, have a mean fitness score of 57.20. This mean fitness score is approximately that of the mean scores of the average and of the entire group. The small boys (those in developmental levels below 100) in all physique channels made a mean fitness score of 50.20. The stocky and obese boys (physique channels A_3 and up) in all developmental levels made the lowest mean fitness score (41.31).

In the obese group, the larger individuals earned significantly higher scores on the physical fitness test than did the average individuals. The critical ratio in this instance was 4.92. Too few cases fell into the short, obese group to be considered in this calculation.

The group with medium physiques, channels A_2 to B_2, showed significant differences between the large and average sized boys and the average and small boys. The critical ratio for the former was 9.18, and for the latter was 3.34. The larger boys in both instances showed the higher physical fitness score, on the average.

The thin physique group, channels B_3 to B_6, produced a critical ratio between the large and average groups of 3.47, and between the average and small groups of 6.13. Again the larger individuals scored higher in physical fitness.

Since a critical ratio of 2.58 is needed for significance at the one per cent level of confidence for samples of these numbers, these critical ratios are significant at a level far beyond one per cent. Differences in mean scores of the groups were too large to be attributed to chance. It seems evident that developmental level contributes a great deal to the physical fitness score attained. The greater the level of development the higher the mean physical fitness score became for all three physique groups.

Considering the differences in physical fitness of boys of specific physique groups within given levels of development, no such consistent increase or decrease, when moving from the obese to the thin group or vice versa, was observed. However, differences were significant in all cases between the obese and the medium groups. The critical ratio between these two groups with developmental levels between 150 to 200 being 5.85, and between these groups with developmental levels 100 and 150 being 8.60. Too few cases were found in the lower developmental group (50–100) to be considered statistically.

The difference in mean physical fitness scores of boys with medium physiques (channels A_2 to B_2) and thin individuals, (channels B_3 to B_6) all with develop-

mental levels from 150 to 200 was insignificant, having a critical ratio smaller than the 1.96 needed for the five per cent level of confidence. The difference between the medium and thin physique groups at 100 to 150 developmental interval, was statistically significant. The critical ratio in this instance was 3.05. The medium and thin physique groups with the lowest developmental levels, 50 to 100, yielded a critical ratio of .22, which was not significant.

These significance ratios indicate that those elementary school boys with medium physiques and thin physiques at the higher developmental levels, made approximately the same physical fitness scores. Likewise those boys in these physique groups and with the lowest developmental levels were not significantly different in the physical fitness test performances. The boys with medium or thin physiques, and with average size, were significantly different in physical fitness scores, with the thinner boys making the higher scores. The obese group showed different physical fitness scores for all levels of development, the differences being statistically significant.

It is evident that considerable differences existed in the scores on the Indiana Physical Fitness Test of elementary school boys of particular sizes and shapes. It seemed advisable to establish norms for this test whereby elementary school boys may be evaluated in physical fitness in terms of performance on the test of individuals of comparable size and shape.

Since the Wetzel Grid is a simple and valuable instrument for the instructor to employ in the physical education program, and since the Indiana State Physical Fitness Test is also simple and efficient as a measure of physical fitness, these norms should be valuable as an aid in comparing obtained physical fitness with physical scores of large numbers of individuals of comparable size and shape.

Conclusions

1. Size and shape seems to have an influence on physical performance.
2. The thin and medium in physique, who are very large, perform equally well physically. The same can be said of the smallest groups.
3. Thin boys of average size perform better than medium physique boys, of average size.
4. The very obese boys are the poorest physical performers.
5. Maximum size and shape does not produce maximum physical fitness.
6. The large and fat boys vary more in physical performance than the normal and thin boys.
7. Within the limits of this study there is indication of a fairly systematic relationship between physique channels and developmental levels according to the Wetzel Grid and the Indiana Physical Fitness Scores of elementary school boys in Indiana.
8. On the basis of the differences which exist in physical fitness scores of groups divided by a combination of developmental level and physique, it seems that norms should be established for performance in the Indiana Physical Fitness Test for these particular groups.

The Status of Liability for School Physical Education Accidents and Its Relationship to the Health Program

NATHAN DOSCHER AND NELSON WALKE

Brooklyn College
Brooklyn, New York

TOO FREQUENTLY judicial decisions in cases where accidents have occurred in sports are looked at by administrators with an eye to avoiding the payment of damages. Such legal acumen is not a fitting approach in a situation where health objectives are dominant. Properly analyzed the legal decisions point the way to improving standards in all phases of physical activities and in many cases to the very preservation of the subject in the school curriculum.

Even if it is accepted that certain potential dangers are inherent in many physical activities, educators cannot continue to claim health benefits for these endeavors if many accidents occur. Furthermore, those who are injured can be economically ruined for life. The care of injuries requires special expensive services which cannot be borne by the individual. Where the state which compels physical activities, with their intrinsic hazards, will hold itself completely blameless when serious injuries occur to the pupils who must participate, then public indignation arises against the subject. The students themselves frequently object, as witness the reaction of Rutgers students to physical activities in defense training during the last war: "Toll of Injuries Among Rutgers Students Stirs Protest Over Physical Education Drill" (1). This type of complaint affects public opinion and eventually judicial decisions.

Early Judicial Decisions

In a case (2) in the earlier part of the century we find this sympathetic analysis of play among school children in the playgrounds. After ruling that a nine-year-old boy was not liable for injuries to another child sustained in a game of tag as a result of a collision between him and the plaintiff, the court went on to state:

> Rule is well established that a minor is responsible for compensatory damages resulting from his torts in the same manner as an adult. The defendant here was engaged in strictly a lawful act. The very purpose of the schoolyard is to allow opportunity for children to play therein and the more vigorous the exercise is during the brief recesses in the school the better is the purpose of the schoolyard subserved. The venerable game of tag in its various forms must have been one of the primary games and it still occupies an honored place among the sports of childhood. Usually harmless and free (of injury) to bystanders it seems a sport not to be discouraged because of its wholesome activity and stirring of the blood. Certainly we should not wish to do anything which would seem to make it necessary for the children to stand about the schoolyard with folded hands at recesses for fear they might negligently brush one of their fellows and become liable for damages. Recognizing that a person might, even

when engaged in lawful activity, conduct himself negligently, it is a further rule that a child must use care according to the understanding, the experience, and capacity of the child. If there be liability for this injury, there is no end to suits and I will not be a pioneer in their instigation.

This decision was handed down at a time when the general rule in law was that a municipal corporation could not be held liable for the negligence of its agents and employees except by its own specific consent. If the plaintiff had brought suit against the school district or municipality, then the court could have ruled that the government agency was not responsible for injuries sustained by a pupil during a public action: namely, the maintenance of play activities in school. On the other hand, the court could have held any individual involved for negligent action and the defendant in this case, the playing boy, might have had to pay for injuries to the youngster hurt. But the court said "No." It stated that the benefits of play offset the few inherent dangers involved therein and would not endanger a complete program in education for the sake of benefiting the person occasionally injured.

Changing Attitude of the Courts

However, when more and more accidents occur in games in which the child must take part for the sake of his health, and where the rule that the state or the school district cannot be held liable because it "can do no wrong," then public opinion begins to strike back. Therefore, without the benefit of legislation to eliminate the archaic common law adage which held the state blameless, decisions began to appear in favor of injured children.

Thus, a plaintiff was able to recover from the New York Board of Education when he was hurt as he fell from a broken springboard in a school gymnasium where the board had notice of the defect (3). In another situation the court held that if a pupil could prove that the floor, on which he had been exercising under the direction of a regularly approved teacher, was defective he could recover for injuries sustained in the activities (4). Other cases which took this line can be cited. This was a divergence from the established common law.

Generally speaking, one is liable in a negligence suit if it can be shown that the injuries to another were the proximate results of the improper actions of the defendant. But states, municipalities, and their duly constituted agents were exempt from this liability no matter how negligent the action of these bodies and their aides were. This immunity derived from the old common law rule that a sovereign got his power by divine right, could do no wrong, and therefore could not be held for his torts unless he benevolently consented to do so. This merely meant that a school board could force a youngster to climb, run, wrestle, box, tumble, play football, jump, hurdle, skip, dance, participate in basketball, indulge in speedball, bat and slide in baseball, and dive, but no matter how seriously he might be hurt in these admittedly inherently dangerous activities the school boards, even if their agents were negligent, did not have to pay a cent toward the rehabilitation of the hurt youngster.

It is pertinent to note here that for a like reason, a similarly harsh rule of law created a severe social circumstance. Under the old employers' liability law, an

individual who might be hurt in an accident on his job could not recover if it were proved that:

1. The employee contributed to the accident;
2. A fellow employee contributed to the accident;
3. An extraordinary occurrence caused the accident;
4. The possibility of the accident was foreseeable as part of the job.

It became quite impossible to recover in any industrial accident when such defenses were applied. While such protection to the employer might have been feasible in a world of hand labor, during a machine age where the margin of error between safety and hazard is gauged only in terms of infinitesimal measurements of tremendous machines (all beyond the comprehension of the ordinary worker), such a law is hard.

Social reaction to this rule was frequently unsalutary. Employers were sought out and killed after decisions against the employers were handed down. To win cases in court, disgruntled, crippled workers resorted to collusion with witnesses and some lawyers. Such social conditions were unsatisfactory and largely the result of an attempt to apply old laws to utterly new and different situations. To atone for such error, workmen's compensation acts were passed by which, generally speaking, employees were to recover for injuries sustained during the course of employment whether they were or were not negligent. This was little more than a recognition of new situations in a technocratic world to which the rules of an old civilization could not be applied with adequate justice.

Ordinarily, the cure for the situation in the case of school liability would lie in statutes which overcame the common law rule. However, when legislators were slow, common law rules have been distinguished by judges so that they could be applied to new situations with plausible justice. This kind of distinction on the part of courts grows out of the influence of public opinion and the innate sense of justice that one arrives at upon examination of the harshness of an old law. In addition, there were recent conditions in society which abetted judges in distinguishing old cases in such a way that a hurt individual would receive his proper desserts.

During the past decade the government went into many social services. Food stamps were issued to the indigent during the last emergency. Rents were controlled so that people could maintain their dwellings. Food was rationed so that each would get something approaching his share. Land and waterways were condemned to provide cheap electricity for indigent rural families. Floors were placed on the prices of farm commodities to keep the tiller of the land out of bankruptcy. These were positive actions by the legislature to improve the lot of mankind in America. In an atmosphere of this kind there is little wonder that decisions against arbitrary rules of state were handed down with greater frequency. This is a logical result where a state charges its agencies with duties for the greater benefits of mankind. Within the meaning of such philosophy, it cannot exercise broad authority in a way that injuries its constituents and still hold itself immune to liability.

The judges, because of the flexibility of the doctrine of *stare decisis*, could make distinctions in their dicta in order to carry out the spirit of the laws even if there seemed to be an apparent contradiction of old rules. Moreover, judicial wisdom frequently is a guide to legislators in enacting proper laws so that judges, in order to protect the individual, for whom the state is created, need not always resort to splitting of etymological hairs to carry out the obvious purposes of government legislation. They need merely act in the spirit of the general prevailing law.

Thus, where physical education is made compulsory for the improvement and maintenance of health (a cardinal principle of public school education), a series of accidents to students during their pursuit of the subject would cause judges to make interpretations in every logical and socially acceptable way possible. It is patent therefore that the rule laid down in *Briese* vs. *Maechtle* might be revised in later decisions.

In a California case (5) where a girl was hurt in a high school activity in which she was performing a "roll-over-two," a common stunt in tumbling, the court made these significant remarks:

> "In deciding whether employees of the appellant used ordinary care it was proper for the jury to consider not only whether the exercise was inherently dangerous but also whether they should have allowed or required the respondent to take instruction in tumbling. It is a matter of common knowledge that some students show much more aptitude for athletics than do others. Some enjoy physical exercise; others find games or stunts of any kind very difficult. Frequently students of the same age have different capacities for physical training. Also, some forms of exercise are considered entirely proper for boys while too strenuous or undesirable for girls. In the exercise of ordinary care it was the duty of the teachers employed by the school district to take all of these factors into consideration in determining the kind of instruction to be given to the respondent. . . . This and other evidence, if believed by the jury, is sufficient to support a verdict for the respondent either upon the theory that the "roll-over-two" is not an exercise suitable for high school girls or that the appellant's employees knew or should have known that because of the respondent's mental or physical condition she was not a proper subject for such instruction, or that the teacher did not properly instruct or supervise her. . . . Under the circumstances shown in this case the issue of negligence was one solely for the determination of the jury. . . . While it does not lie within the province of the jury to determine whether certain subjects should be taught, school authorities may be guilty of negligence in requiring a student to take a particular course of study. . . ."

In spite of the court's note to the contrary, this in effect permits the jury to state what a safe high school physical education curriculum is. Moreover, the court does not seem to accept *per se* the virtues of physical education as a builder of health.

A year later (1939) in New York (6) recovery was allowed to a student in the elementary schools when she was injured in a headstand, on the basis that the exercise was an unreasonable one. Here the judge flatly defines what should not be in the curriculum. Judges and juries are deciding educational principle! As shall be shown later, such a situation can come about only when educational theorists permit practice to lag behind public opinion.

Factors Contributing to Changes in Attitude

Perhaps one of the major factors contributing to such change in official attitude lay in the economic jest perpetrated upon the public in cases where the individual was hurt in an accident in physical education. In the cases where negligence was established, the courts stated that the recovery had to be got out of the pocketbook of the teachers.

Assume that a judgment of several thousand dollars is awarded to a plaintiff. It is known that the average salary of teachers in public education is in the low $3,000 to $4,000 bracket. It could be that the recovery, if had, would mean the garnishment of the teacher's salary for life without complete satisfaction of the judgment. It would mean an unjustified punishment of a teacher who was carrying out his duty as well as humanly possible at the time of the accident.

When a teacher has classes of 200 students, how can he possibly watch every bit of activity on the gymnasium or school grounds? A normal-sized class in physical education, if all the modern principles involved in teaching the child and providing for his individual differences are adhered to, consists of 25 students. Indeed, in some of the admittedly dangerous areas a teacher is needed to supervise each activity of the child. This is so in boxing, high bar gymnastics, ground tumbling, and many other activities. Yet the judges, in order to attain some modicum of realism in these situations where principles are negated by the actual procedures used in schools, have made decisions that could result in much hazard to the school child.

Here is the gist of some of these *dangerous* decisions:

> No amount of reasonable supervision will prevent some accidents (7).
> It is sufficient if a general degree of supervision has been provided (8).
> Sufficient supervision is provided for an entire playground if only one or more competent instructors is provided (9).
> A single attendant for 200 in a playground is adequate (10).
> A single lifeguard is sufficient for a swimming pool (11).
> Minute supervision of a locker room is not required by law (12).
> Nor is a small army of attendants necessary for the supervision of so-called supervised play activities (13).

It is interesting to note that one of the above decisions (the Collentine case) involved a situation in which the court expressly refused to apply the law in the case of *Miller* vs. *Board of Education* where the court said:

> Of course the most complete way of stopping injuries is either to stop all athletic activities or perhaps provide a supervisor for each piece of playground apparatus. (14)

These decisions were all handed down before laws were passed to hold the state liable for negligence in these school accident cases. Note that it is accepted that accidents are inherent in athletics. Yet to avoid this type of hazard a judge stated that merely a degree of general supervision was adequate. Another judge says that one attendant for 200 children is sufficient. This is in direct contrast to a case against a private owner of a carousel where, because much danger was involved (inherent risk of accidents), the operator was held liable

for exercising the most extreme degree of care, the court stating that everything conceivable should have been done to prevent accidents (15).

Where hazards are inherent in the activity itself, it seems that something more than the court rule (i.e., that one instructor is sufficient for many, many children participating in many activities) should hold. As has been shown previously, cases have been decided which contradict this rule of accepting loose, general supervision as sufficient. Indeed, courts have followed the decision in the Miller case by ruling certain activities as unreasonable. In sports like boxing, football, and swimming where not only are injuries plentiful, but death fairly frequent, perhaps it is the better part of wisdom to have a small army of teachers and supervisors to care for the activities.

It certainly is ridiculous to accept one teacher for 200 students when the very principles of physical education call for a ratio of one teacher to 25 in ordinary classroom activities. To say that one guard is sufficient in a pool is absurd. Who teaches while this one fellow guards? What lifeguard can patrol a diving board and still care for the beginning swimmer wallowing about in semi-deep water? The court rule on this is extremely dangerous. This amounts to a splitting of hairs to save a teacher or board of education from living with a bad conscience where the negligence is widespread and no one wants to blame anyone else. Under such circumstances, where the school authorities fail to follow principles and provide adequate teachers, facilities, and equipment, the physical education program will be emasculated or eliminated by more enlightened court order. In addition, under the new type of law now in effect in New York State some small communities may be bankrupt in lawsuits for accidents, and education generally may be put in a bad way under such circumstances.

Present Laws and their Implications

The New York State law has important implications. California has a similar law. Three other states have legislation of a like variety. These laws may be as significant in accident prevention in athletics as was the Workmen's Compensation Law among workers. Section 2510 of the New York State Education Law states:

> Notwithstanding any inconsistent provision of law, general, special, or local, or the limitations contained in any city charter, the board of educations, in a city having a population of one million or more, shall be liable for, and shall assume liability to the extent that it shall save harmless, any duly appointed member of the teaching or supervizing staff, officer, or employee or such board, for damages arising out of negligence of any such appointed member, officeer, or employee, resulting in personal injury or property damage whether within or without the school buildings, provided the appointed member, officer, or employee at the time damages were sustained was acting in discharge of his duties within the scope of his employment.

New York Stated Education Law, Section 3023 enacts similar legislation for cities under one million and adds the right of the city to insure itself as protection—"saves harmless and protects all teachers from financial loss arising out of any claims, demands, suits, or judgments by reason of alleged negligence or other act resulting in accidental bodily injury to any person within or without

the school building." The insurance serves to enable the smaller school district to conform to this law and still remain financially solvent.

Under this law the king and his henchman can err! Has this made any difference in the status of the injured child at the bar of justice? What have the courts stated on this matter in view of the new law?

> This section was passed for the exclusive benefit of teachers (16).
>
> This section was intended to create direct liability on boards of education to an injured person for damages sustained through negligence of the board's employee and to impose liability on the board by way of indemnity (17).

One of the direct decisions under this section, while not an athletic situation, is pertinent. In *Edkins* vs. *The Board of Education* (16) a student had his thumb crushed in an attempt to disentangle his sweater from a lathe. The school failed to provide a protective apron. The court said that Section 2510 makes it the duty of the board to "furnish equipment as might be necessary for proper and efficient management of education activities under the board's management and control." The board was held liable.

Other decisions state that the board of education is liable where a child is hurt by a passing car in a touch football game conducted on a school street by the authorized teacher during school period (19), and that where a slide in a school falls over a child that there is sufficient evidence of negligence for the case to go to the jury (20).

In short, the teacher is no longer liable. Moreover, the board will be held for supplying proper equipment, recreation areas, and perhaps athletic clothing if the Edkins case is adhered to liberally. It is also significant to note that a short time after the law was passed, the New York City Board of Education required all of its teachers to take a course in first aid. This followed from the fact that the courts have held that a teacher is responsible for applying first aid where a child is injured. Not to have had teachers competent in first aid might have added to the amount of negligence the Board of Education could have attributed to it.

This type of law and the decisions under it leave no question as to whom the courts will hold responsible for accidental injuries to children in physical education activities. It will cost the board of education money to allow negligence of any of its teachers. The boards are always economical, if not downright parsimonious, and the action of the courts in New York may mean the end of lip service to safety in athletics and the actual application of safe practices in sports.

The nature of athletics and the inherent injuries therein, if this be a true evaluation of the situation, coupled with the interpretations of the courts, will force the schools to do what industry did when workmen's compensation laws became prevalent. They will have to abide by principle or pay extremely high monetary costs. If they fail in this, they may decide to drop physical education from the curriculum. To avoid this latter possibility, the profession of physical and health education should insist on principles being applied, or else the subject may pass into the limbo of the lost. Courts have killed some activities.

Medical authorities have questioned the need for any exercise beyond that involved in daily routines. The situation is not uncritical. Only the application of educational principles in every respect will make certain a perpetuation of physical education.

Survey of Cases

Since the schools are now liable in several states and the trend may spread to others, an examination of the immunity of the schools in the past and of the possible future changes is worth considering as a key to the kind of action that schools must take to save themselves harmless in future legal suits, and eventually to clothe physical education with the health-giving values it intrinsically embodies.

Rosenfield[1] has listed hosts of cases in which the state or its agency could not be held liable even if negligence was proved. This, as has been stated, involved a strict application of the law which stated that the sovereign could not be sued without his own consent. It has been shown also that under the common law rule of *stare decisis* many courts did attempt to adjust legal thought to the trend of the times and made astute distinctions by which they were able to hold a school board liable for an injury to a child where negligence was proved. And finally in five states, by statute (legislative consent) school boards assume the liability of their agents for injuries to pupils when negligence can be proved. A brief review of some of the significant cases will be helpful in orienting a program in physical education activities which will cut to a minimum the number of accidents in physical education.

Here are sets of facts which have appeared in the past where it was possible that the school boards would be immune to suit even if negligence could be proved. Except in states where statutes to the contrary appear these represent the law:

1. Failure to use mats against a brick wall which was used as a finish line in a foot race (21)
2. Failure to employ mats on a floor used for gymnastic stunts (22)
3. Failure to use mats in a gymnasium used for field dodge ball (23)
4. Failure to prevent gymnasium lockers from falling on students (24)
5. Maintenance of a portable backstop which is insecure and can fall (25)
6. Keeping a piano on a dolly which falls when a student does jumping exercises in a regular physical education class (26)
7. Unslaked lime (used to line a football field) which blinds a player (27)
8. Collapse of bleachers on students (28)
9. Bleachers constructed so that a car could ride over embankment and kill spectator (29)
10. A temporary grandstand negligently erected for school purposes within the school building (30)
11. Use of a swimming pool without supervision (31)
12. Only a bath attendant present at a foot race in a school and no negligence existed (32)
13. No inspection for safety in playgrounds (33)
14. Children hit during play periods on school grounds by automobiles, school buses, and official vehicles (34)
15. Children hurt while playing on school grounds during periods after school, during the summer, during evening sessions, and during community center activities (35)

[1] Rosenfield, Harry N. *Liability for School Accidents.* New York: Harper and Bros., 1940.

On the other hand, because of the inequities in the situations, the necessity of drawing "life-blood" out of teachers for purposes of recovery, and the greater respect for the individual that had appeared as a general government philosophy, the old rule of the sovereign could do no wrong was distinguished in the following groups of facts, and the state or its school agency held accountable.

1. The use of a slippery balance beam on an oiled floor without a mat (36)
2. A child is hit by a swung bat which has no knobbed handle (37)
3. A springboard which splits when used (38)
4. A dangerous swinging gate in a playground (39)
5. Use of a perpendicular ladder rather than an oblique one for approaching a slide (40)
6. Swings maintained and placed unsafely (41)
7. Lack of proper supervision to spell out care (42)
8. Children permitted to use a playground which is likely to cause injury (43)
9. A teacher failed to lock a gymnasium and keep children out of it during a non-supervised period (44)
10. Children piled up books in a playground and children tripped on them (45)
11. A football coach, who knowingly sends back into a game injured player, or who did not know the player was injured and used him in a game (46)
12. A football coach who did not adequately safeguard his players (47)
13. Sending a ball player into a game where the player is known or should be known to be ill (48)
14. Rowdyism during a school game (49)
15. Injuries during athletic practice (50)
16. Injuries to a spectator watching practice or a contest (51)
17. A child falls into a hole on the school grounds
18. A child falls into a depressed basement next to a play area where no guard rail is provided (52)

Trends for the Future

What will the trend in the future be in the states with legislation eliminating the rule that the state can do no wrong and in those other states to which such socially correct interpretation of the laws of negligence are adopted eventually? This can best be seen from a brief examination of those cases where private persons and groups have been involved. The laws of negligence applied to them completely. If a person was injured as a proximate result of the wrongdoing of the private individual, then he had to pay in law. His only defenses lay in the contributory negligence of the injured party, in the foreseeability of the possible injury by the injured party, or in the inevitability of the accident.

Many of the cases decided, where ordinary rules of negligence apply, and in which the defendant was held liable, approximate situations in which the schools formerly have been held immune. As an ameliorating circumstance there have been some unusual interpretations where the individual has been held not liable even though the facts, on their surface, seemed quite incriminating. These cases will be presented in separate summaries below. The significant point here is that the schools should expect no more immunity than do the private individuals where legislation has eliminated blamelessness.

In July of 1951 the Brooklyn Dodgers were held accountable when a woman was hit by a pop bottle flung by a patron. This would seem to eliminate any question as to whether a school will be liable for injuries resulting from the

misconduct of the students and spectators at games. The court said that "one who collects a large number of people for gain or profit must be vigilant to protect them" (53).

Other cases in point are:

1. When a person was hurt at a ball game, the court said screens must be provided in dangerous areas (54).

2. When notice is placed on a ticket, the owner may limit liability but the warning must be brought to the attention of a patron in such way that a person of ordinary intelligence would understand it.

3. A patron was hurt in a ball game and sued. The court stated the general rule "that operators and owners of baseball parks are not insurers of safety, but being in the business of providing public entertainment for profits, they are bound to exercise reasonable care, or the care commensurate with the circumstances of the situation, to protect the patrons against injury" (55).

4. An employee of the defendant was hit while watching a ball game provided for the entertainment of the workers during their lunch hour. The court held that the game was provided to develop rapport between management and worker and that the employee was hurt during the regular course of employment and therefore the company was liable (56). (The possibility of children watching teams practice during lunch periods, and being hurt during the course of this time or under similar circumstances might be interpreted by courts in line with this case.)

5. Plaintiff, an employee of the defendant, slipped on the floor while watching a game provided for recreation of employees by the defendant management. Recovery was allowed (57).

6. A school principal was hurt while he was selecting a basketball team. This was part of his stated duty. He sued and recovered (58).

7. The plaintiff employee played soccer on a team organized by the defendant employer (corporation) and was hurt during participation. The court held for the plaintiff on the ground that the defendant obtained good will through these games (59). (The situation among basketball and football players who play national schedules for colleges could well be compared to this case. Of course negligence would have to be proved, as in any case, but the idea that the college secures much good will from these games could make the measure of care afforded players one that envisioned every possible possibility of damage rather than the rule of mere foreseeable damage. Boys who travel around the country and play on strange courts night in and night out may require exceptional care rather than ordinary care.)

8. In Louisiana an operator of a municipal golf course was held responsible for the negligence of employees (60).

9. Here is a group of interesting cases with respect to swimming situations.

a) A lifeguard, in his attempt to save a person, pulled the plaintiff (drowning one) in such way as to hurt him. The plaintiff sued and recovered. The court stated that the resort had to keep a lifeguard or his equivalent on duty but that the latter had to exercise due care in saving people's lives (61).

b) A plaintiff was pushed into the pool by children who were playing. The plaintiff sued and recovered. The court held that the pool operator was negligent in not providing safe conditions for the activity (62).

c) The plaintiff was hurt when he stepped on glass in shallow water. Recovery was allowed (63).

d) The plaintiff was hurt when a person dived upon him. He sued and recovered. There was lack of proper supervision said the court (64).

e) Plaintiff was hurt by a blown umbrella on a beach. Plaintiff recovered (65).

f) Plaintiff dived into shallow water and was killed. His estate recovered on the ground of insufficient warning of the depth of the water (66).

10. The plaintiff was hurt when the stands collapsed. He sued the Philadelphia Nationals and recovered (67). (This would seem to make the future duty of the schools in conducting spectator sports quite clear.)

11. Two children were whirled off a carousel. The defendant claimed he used care proper in the situation. However, the court stated that the operator of the carousel had to do every thing conceivable to prevent accidents in this kind of case (68).

12. People were hurt on a scenic railway. The doctrine of *res ipso loquitor* (the facts speak for themselves) applied. This kind of apparatus (shoot-the-chutes) is extremely dangerous and the burden is on the operator to show that he did everything he should to avoid the accident (69). (In the future heavy apparatus may be evaluated by this standard.)

13. A nine-year-old boy was driving a miniature car. The car got caught between two loose boards. The boy was hurt because of the impact. There was recovery on the ground that this was negligence (70). (This case may be important when schools adopt as a general procedure the training of drivers who practice on school auto ranges. This set of facts and the one cited in the merry-go-round case above could have an important impact on the care necessary to be exercised in playgrounds, nursery schools, and kindergartens where many forms of merry-go-round and miniature cars are supplied for the use of the children.)

14. A person was hit by a ball as he used a passageway near a ballpark. He had been invited to use this passageway. He sued and recovered (71). (The use of streets by children going to school where the avenues are near school stadiums might be made parallel to this case in the courts.)

15. A child was hit in the face by a striking bag which he punched at a concessionaire's. He was hurt and recovered in a suit on the ground that no adequate warning of the hazard was given (72).

The cases above represent a series of facts wherein schools involved, when judged by the same rules as independent entrepreneurs, will be made to pay for damages. Lest the institutions of public learning become frightened and take recourse in a policy of no action in physical education, it behooves the reader to note that in all of these cases negligence was proved by a preponderance of evidence. Where no negligence is proved, no liability exists. Here are a series of facts in which there was a judgment of non-liability.

1. No screens are needed around the bleachers at a ball game. The danger is not great in this area (73).

2. If a patron picks a seat, either out of choice or because there are no other seats available, at a ball park and he gets hurt, then he has contributed to the negligence and cannot recover (74).

3. An owner of a bowling alley kept cuspidors about the area. A plaintiff was hurt when he tripped on these. This plaintiff also got a splinter on a loose board. The court held that the owner could keep cuspidors around, if he did so reasonably, and since it was a custom of such establishments. As for the splinter, the owner could not be held if he were not notified of the defect. There was no recovery (75).

4. A paying spectator was hurt while he was standing along the sidelines of a football field. Two players had rolled over the sideline and hit the plaintiff. There were no barriers. The court held that barriers were not necessary and that when they were built they were constructed to keep the spectators off the playing field rather than to protect them. The spectator could anticipate such accident and had no standing in court. The management was under no compulsion to provide a fence (76).

5. These facts with respect to golf are pertinent.

a) The plaintiff was hurt by a golf ball and contended that the ordinary rules of negligence did not apply but that extreme care had to be shown by the defendant golf course operator. The court stated that this was not so and that the entrepreneur had to exercise only the care that an ordinary prudent person would exercise under the circumstances (77).

b) Plaintiff was hit by golf ball and claimed that the player was negligent in that he could not control ball he hit. The court stated that to expect man to hit a ball in a completely controlled trajectory was to claim man was perfect muscularly. The golfer is not an insurer of safety and need exercise only the care of the ordinarily prudent person (78).

6. A circus animal hurt a patron. The court said that the rule of care was proper restraint of the animals (79).

7. A child was found drowned in a pool after the establishment had closed. The court said that the entrepreneur was not liable because neither the owner nor lifeguards had been given any indication of the danger to the child (80).

8. As a general rule, neither spectators nor passers-by can recover in court.

Thus it is seen that the schools should have no fear of being prosecuted and held liable for every little accident that occurs. The courts will reason and determine negligence on the facts in the case. If the school authorities have done everything a prudent person would have done under the circumstances then there is little to worry about legally. The courts have even taken cognizance of the inevitability of accidents. The authors believe that such a doctrine has no place in accident prevention programs but cites the following cases where the courts have given cognizance to this theory to show that the judges act, not too severely, but frequently extremely rationally in some of these situations.

1. A boy was struck by a ball thrown from outside the school. The accident was unavoidable and therefore no recovery was allowed. It is interesting to note that this decision was handed down after legislation was enacted by which the state could be held liable (81). A similar decision was handed down in California where two boys collided in a tag game (82).

2. A boy was hit by a baseball bat. The court held that this was not avoidable (83).

A statement of some of the decisions handed down by the courts in New York and other states after the enactment of laws holding schools liable also tend to show that no especially zealous vengeful prosecution of schools will result therefrom, but that unless safety is provided the schools, not the teachers, will be held liable.

1. Children shall not play in a hazardous schoolyard unless it is supervised (84).

2. A child was hit by a bicycle during a free play period and recovered in a court action. The ground was that no provision for the safety of nonparticipants was made (85).

3. A pupil teacher is not a competent supervisor to oversee physical education activities (86).

4. It is negligence to compel pupils to participate in certain kinds of exercise without determining in advance their particular aptitude therefore, especially when the teacher knows of certain adverse conditions (87).

Other decisions have been stated under Section 2510 of the New York State Education Law above.

Safety Implications for Educators

If the safety implications of the judiciary statements are fully comprehended, educators will understand that the best way to avoid serious financial inroads because of decisions in accident cases is to act non-negligently. This means applying all the controls for safety in athletics and the preclusion of subterfuge to avoid legal suit so often used by schools. An example of this underhand way of attempting to avoid suit, rather than applying safety is the statement parents and sometimes adolescent high school and college students, are asked to sign by which they waive all rights to damages in cases of injuries in athletics to the children who play. This is supposed to exercise moral suasion against suit.

This takes advantage of the desire of children to play and frequently avoids the need of setting up safe conditions. The rule with respect to the statement

signed by the child is that it is invalid. Minors cannot sign away their rights. As far as the parents go, they can sign away their rights to damages but the child can sue nevertheless. Such attempts to avoid legal suit, rather than acting safely, can be of little avail in producing a safe, health-giving athletic program. The way to achieve this has been pointed out by the educators and emphasized by the judiciary. Legislation in some states has made it very pertinent that safety rules be applied if physical education activities are not to be eliminated or emasculated.

The controls for safety in physical education, which includes all forms of sports and athletics, lie in:

(a) Legislation to compel safety.

(b) School administration that abides by law and regulates play situations for safe play.

(c) Leadership that guides children into joyful, well-supervised game situations.

(d) Provision of proper facilities.

(e) Provision of proper equipment.

(f) Children trained in safety habits.

Addendum

Date: September 18, 1951

Source: New York World Telegram

Topic: Liability of schools for accidents to pupils

Substance: The Board of Education (New York City) announced today that it will pay a claim of $5000 filed against a public school teacher as a result of injuries sustained by a pupil. The injured pupil was struck in the eye by a blackboard eraser thrown by another pupil. The accident caused the loss of one eye. The claim was made against both board and teacher. The case against the former was dismissed on a technicality. The school board, however, paid the claim against the teacher without a contest on the ground that the New York Statute discussed above save the teacher harmless from damage suits arising out of his performance of duty.

Comment: The law, where a statute such as Section 2510 of the New York Education Law exists, is clear. The authors emphasize that, in their opinion, this is a trend which must force physical education to apply principles of safety in all its teachings or face the danger of elimination, wholly or in part, from the health program.

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Measuring Speed and Force of Charge of Football Players

EDWIN R. ELBEL AND DONALD WILSON
University of Kansas, Lawrence, Kansas
CLARENCE FRENCH
Central High School, Kansas City, Missouri

OF THE NUMBER of factors which go into the making of a football player, it would seem that two are of real importance. These are the speed of charge and the force which can be exerted by the player during the charge. It would seem that the improvement of coaching techniques would, to some extent, depend upon the employment of adequate measuring devices for determing the extent of improvement in complex body movements.

The extent to which complex movements such as the football charge and the track start, need to be practiced before the maximum level of performance is reached has apparently not been well established. If it can be shown that after reaching a certain level of response, the player shows no improvement in the skill in question, the emphasis upon teaching other skills would perhaps prove more profitable. Since such investigations are dependent upon the development of adequate methods of measurement, the following study was done with the hope of making a limited contribution in attempting to measure the speed of charge and the horizontal force of charge of the football player.

Statement of the Problem

The purpose of this study was to devise a method for measuring the speed and horizontal force of the charge of football players by the use of an especially constructed apparatus and to determine the relationship between body weight and force of charge, body weight and speed of charge, and speed of charge and the amount of force exerted.

Review of Literature

Although it is recognized that there are certain similarities relative to all response-time studies, only two studies were found for review dealing specifically with the response time for the charge of the football players. Miles[1] used a multiple chronoscope for measuring the charge of the entire football line simultaneously. The players assumed the normal offensive stance, each with his head against a vertical trigger in front of him. A string attached to the trigger was in turn attached to a latch. When the player charged, the string released the latch, allowing a golf ball to drop onto a large revolving paper-covered drum. Reaction time was computed by measuring the distances from

[1] Miles W. R. Studies in Physical Exertions: II Individual and Group Reaction Time in Football Charging. *Research Quarterly*, Volume 2, October 1931, pp. 5–13.

the point on the paper at which time stimulus was given to the point at which the golf ball struck the drum. The word "hike" was used as the stimulus for the charge. The results of his findings were compared with the subjective judgment of the coach relative to the speed of the players.

Using the same apparatus which was used in the present study for measuring the force exerted, Rosenfield[2] completed a preliminary study in 1949 in which he used freshman football candidates at the University of Kansas. The details of Rosenfield's study differed in many respects from the present study. A bell was used as a stimulus and the charging distance was 12 inches instead of 36 inches as used in the present study. As subjects, Rosenfield used members of the freshman football squad. The subjects for the present study were members of the varsity squad. Comparable data for the two studies are shown in Table 2. Rosenfield, after analyzing his data on 55 freshmen football squad members, arrived at the following conclusions:

1. There was no significant relationship between the force exerted in the charge of a football player and the speed of a charge. (r + 0.09)
2. There was a significant coefficient of correlation between the force exerted and the weight of the individual. (r + 0.51)
3. There was no significant relationship between the weight and speed of charge as evidenced by the coefficient of correlation of −0.08.

Procedure

An especially constructed piece of apparatus was used for the purpose of measuring the speed of charge and the amount of horizontal force exerted by each of 45 members of the University of Kansas varsity football squad.

No distinction was made between the players relative to the various positions for which they were candidates. Also, no attempt was made to completely analyze and measure the total force exerted by the player. Only the horizontal component was considered.

Each subject was tested individually under the following conditions:

1. Each was wearing a complete football uniform.
2. No strenuous exercise was allowed prior to testing.
3. Each subject was given the benefit of a standardized set of instructions during an indoctrination period.
4. Testing was done at relatively the same time each day.
5. Four trials of each subject were allowed.
6. Subjects assumed the football charging position with hands behind a line 3 feet from the dummy.
7. One investigator did all of the testing.

APPARATUS

The apparatus consisted of a horizontal "I" beam mounted upon grooved rollers to which a vertical arm containing a padded "dummy" was attached by a hinge. One end of a calibrated spring was attached to the sliding "I" beam while the other end was secured to the base-plate of the apparatus. Force

[2] Rosenfield, Richard J. *Measuring Reaction Time and Force Extended by Football Players.* Unpublished master's thesis, University of Kansas, 1950, p. 34.

exerted upon the dummy caused an elongation of the spring. The amount of force exerted was measured by means of an especially constructed scale (ranging from 0 to 600 pounds) attached to the base-board of the apparatus. A pointer moved with the beam and remained in place, until reset manually, indicating the amount of force exerted in pounds. A spring was attached to the "dummy-arm" to absorb the initial impact of the charge. Rapid recoil was prevented by means of a mechanical door-closer which was attached to the "I" beam.

To prevent lateral movement, the "I" beam moved upon grooved rollers mounted upon the base-plate. Heavy casters fastened to the brackets exerted pressure on the top of the "I" beam, thus preventing the rear end from tilting upward when force was exerted upon the "dummy."

As a means of measuring the speed of charge an electric clock, graduated in in one-hundredths of a second, was placed in circuit with a microphone, an amplifier, and the charging mechanism. The investigator counted rhythmically in a uniform tone below the range for which the amplifier was set. A pre-determined "snap signal", which was given with greater volume, served as a stimulus and activated the clock. When the subject struck the dummy with his shoulder, a micro-switch "broke" the circuit to the clock (Figure I).

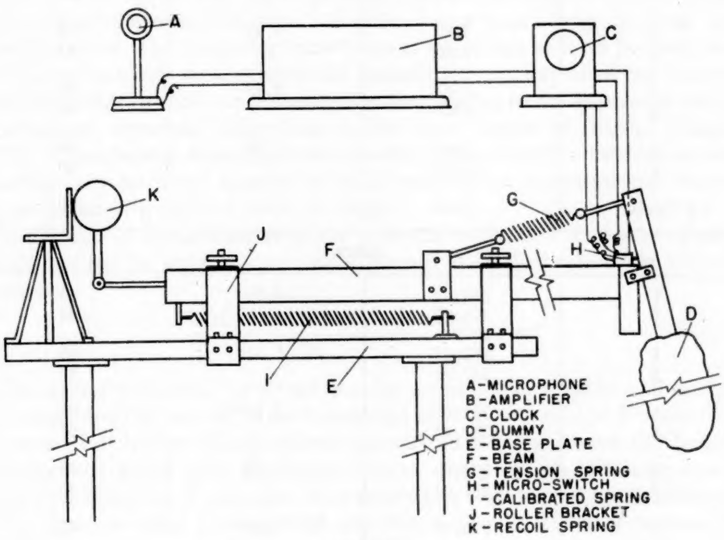

Fig. I

Results

Means and standard deviations for speed of charge and for the amount of force exerted were computed for each of the four trials for all subjects. The composite means for speed and force of charge were also computed. The t ratios for the difference between the means for each trial were also determined. Pear-

sonian coefficients of correlation between weight and speed of charge, weight and force of charge, and speed of charge and force exerted were computed.

The means for all subjects in each trial for speed of charge and force of charge are contained in Table 1. Only four trials were required of each subject for measuring the speed of charge and the same number for measuring the force

TABLE 1

Means and t *Ratios for Each Trial for Speed of Charge and for the Force Exerted During the Charge*

Comparison of trials	Mean	*t*	*N*
		SPEED	
1	.5667	3.64*	45
2	.5564		45
1	.5667	2.18	45
3	.5302		45
1	.5667	2.17	45
4	.5285		45
2	.5564	1.49	45
3	.5302		45
2	.5564	1.43	45
4	.5285		45
3	.5302	.82	45
4	.5285		45
All Trials	.5340		180
		FORCE	
1	252.67	4.60*	45
2	274.99		45
1	252.67	5.32*	45
3	287.91		45
1	252.67	3.14**	45
4	282.44		45
2	274.99	2.03	45
3	287.91		45
2	274.99	.69	45
4	282.44		45
3	287.91	.63	45
4	282.44		45
All Trials	266.75		180

* Significant on the 1 per cent level.

** Significant on the 5 per cent level.

of charge. For the difference between the means for each trial, t ratios were computed. Since there were $\frac{3 \times 4}{2}$ or 6 possible comparisons of twos for each of the two variables, the required probability for the selected difference to be significant is set, therefore, not as 1 in 100 but 1 in 6 (100) or 1.6 in 1,000. The t ratios having probability values of less than approximately 1.6 in 1,000 are significant on a 1 per cent level, and those having probability values less than approximately 8.3 in 1,000 are significant at the 5 per cent level.

Considering the speed of charge, the means became smaller for each of the first three trials. The mean for all subjects for the first trial was .5667 seconds; for second trial, .5564 seconds; for the third trial, .5302 seconds; and .5285 seconds for the fourth trial. The mean for all trials for all subjects was .5340 seconds. The t ratio computed for the difference between the means for the first and second trials was found to be significant at the 1 per cent level. The t ratios computed for the difference between the means for other trials were found not to be significant on either a 1 per cent or a 5 per cent level.

The mean amount of force exerted became greater with each successive trial from the first through the third trial. The means for successive trials being 252.67, 274.99, 287.91 and 282.44 pounds. The t ratios computed for the difference between the means for trials 1–2 and 1–3 were found to be significant on a 1 per cent level. The t ratio for trials 1–4 was significant at the 5 per cent level.

Since the subjects were experienced football players, any observed improvement from trial to trial was probably due to adapting to the apparatus and the experimental situation rather than in the improvement of football charging ability. Considerable experimentation would perhaps need to be done in order to adequately learn the number of trials necessary to determine the limits of improvement in speed and force of charge.

As a means of determining standard scores for subjects, T scales for speed of charge and for the force exerted were constructed on the basis of the following formula:

$$\frac{6 \times \text{Standard deviation}}{100} \text{ Increment}$$

The mean for all trials for all subjects for speed (.5340 seconds) and for force of charge (266.750 pounds) were considered as 50 points on the T-scale. Since the measuring devices did not measure exactly all of the values on the T-scales, T-scores were based upon the nearest figure. The subject's test score was secured by adding the T-score for force exerted to that for the speed of charge.

The greatest mean force exerted was 362.75 pounds with a T-score of 80. The fastest mean speed of charge was .2800 second with a T-score of 83. The highest combined T-score (force plus speed) was 143 with a mean performance of .2800 second for speed (T-score 83) and 302.75 pounds for force exerted (T-score 60). The poorest performance gave a combined T-score of only 54 with a mean speed of .6725 second and a force of 167.50 pounds. The subject with the best score for speed also received the highest combined T-score. The subject exerting the greatest force received the third highest T-score.

The coefficient of correlation between body weight and force exerted was found to be +0.30 which is significant at the 5 per cent level. Speed of charge and force are not related as evidenced by the insignificant coefficient of correlation of +0.06. Body weight and speed of charge are inversely related as shown by the significant negative coefficient of correlation of −0.51. The coefficients of correlation between the variables are shown in Table 2.

TABLE 2

Results Obtained by Rosenfield As Compared to Results Obtained in Present Study

Activity	Rosenfield		r	N	Present study	
	N	Mean			Mean	r
Speed	55	.5436		45	.5340	
Force	55	262.6		45	266.75	
Force vs. speed			+0.09			+0.06
Force vs. weight			+0.51*			+0.30**
Weight vs. speed			−0.08			−0.51*

* Significant on the 1 per cent level.
** Significant on the 5 per cent level.

It is interesting to note that in the study done by Rosenfield in which he used freshman football squad members as subjects, the coefficient of correlation between body weight and the amount of force exerted was found to be significant at the 1 per cent level (+0.51). In the present study, the coefficient of correlation between the two variables was found to be significant at the 5 per cent level (+0.30). Relative to body weight and speed of charge, Rosenfield found no significant relationship between the two variables (−0.08). In the present study, correlation between body weight and speed of charge for the more experienced player, weight appears to be a handicap to speed. The results of the two studies agree in that there is no relationship between the speed of charge and the amount of force exerted.

Summary and Conclusions

Speed and horizontal force of the football charge were measured by means of an especially constructed piece of apparatus whereby the extent of the elongation of a coil spring on the tackling dummy was used as a measure of the amount of force exerted during the charge. Using an electric time-clock, the elapsed time between the instant that a vocal stimulus was used and the instant that the subject struck a padded dummy with his shoulder was considered as a measure of the speed of charge.

Forty-five University of Kansas football squad members each wearing a complete football uniform were used as subjects. *T*-scales were constructed for speed of charge and for the force exerted. These conclusions were reached:

1. There was no relationship between speed of charge and force exerted.

2. The coefficient of correlation between body weight and force exerted was found to be significant on a 5 per cent level of probability (+0.30). The relationship could scarcely be considered significant for predictive purposes.

3. There is inverse relationship between weight and speed of charge (−0.51).

Force-Time Characteristics of the Sprint Start

Franklin M. Henry

University of California
Berkeley, California

Several pioneering studies at the University of Iowa on the sprint start, summarized by Bender (1), were published in 1934. Apparently there have been no later investigations of the subject reported in the research literature.

Review and Discussion of the Literature

Kistler (3) attached starting blocks to the platforms of two spring scales which were sunk below the track surface so that the blocks were in a normal position. Measuring the front leg thrust at a 45-degree angle and the rear leg thrust nearly parallel to the ground, he reported that with a toe-to-toe longitudinal foot spacing of 11 inches, 30 sprinters average 195.3 pounds pressure from the front foot and 150.7 pounds from the rear foot. With a spacing of 26 inches, the front foot produced almost exactly the same thrust, 196.0 pounds, but the rear foot pressure increased to 208.3 pounds. Intermediate spacings tended to yield intermediate pressures, the sum of the forces from the two feet being 346 pounds for the 11 inch or bunch start, 303 pounds for the 16 inch spacing, 386 pounds for a 21 inch separation and 404 pounds for the 26 inch or elongated stance. These results suggest that the elongated stance results in the most powerful start.

Somewhat in contradiction to this finding, Dickinson (2) found that the average time required for ten men to run 2.5 yards, as measured with an automatic chronoscope actuated by the starting gun, was only 0.806 seconds for the bunch start as compared with 0.887 seconds for the elongated start. Intermediate or medium stances resulted in intermediate speeds. It may be calculated (4) that the advantage in speed derived from the bunch start means that the runners using the elongated start would be 13 inches from the 2.5 yard tape at the instant that the bunch start runners crossed it. Dickinson also observed that in 26 sprinters, the average time required to get clear of the blocks (including reaction time) was 0.244 seconds for a 10.5-inch bunch start, 0.326 seconds for a 21-inch medium start and 0.387 seconds for a 26-inch elongated start. The shorter time on the blocks with the close-coupled stance would of course be expected since the legs of the runner do not have to move as far as with the elongated start. Some coaches think that the bunch start offers an advantage because it places the runner's center of gravity a few inches closer to the starting line and, therefore, closer to the finish tape. Dickinson's data on foot placement indicate that this probably does not happen; the distance from the starting line for the front and rear feet averaged together was slightly greater for the bunch than for the medium stance.

Neither of the studies reviewed above permit predicting which starting stance is most effective in a typical dash run. It can be argued that other things being equal, the more powerful start secured from the elongated stance should result in a faster dash; it can be argued with equivalent justification that the bunch start will result in a faster dash, since the sprinter gets off the blocks more quickly. Or it may very well be that by the time the runner has progressed 50 or 100 yards, other factors affecting speed may almost completely overcome the advantages or disadvantages of a particular starting stance.

Moreover, a more forceful start must necessarily, on straightforward physical grounds, impart a great velocity to the runner's body mass. Even though the greater velocity is secured at the expense of an initial time loss, it should result in a faster run although the sprinter with the quicker but weaker start may lead for a few yards. Consider a simplified example: Runner A leaves the blocks with a velocity of two yards per second, and reaches four yards in two seconds (neglecting frictional losses and similar factors). Runner B gets under way a tenth second later but leaves the blocks with five per cent higher velocity. At one second after the gun he will lag a tenth yard behind B; at two seconds he will catch up with him and thereafter will be in the lead. Using this reasoning it is possible to reconcile the contradiction between the results of Dickinson and Kistler: At some distance greater than 2.5 yards, the initial advantage of the bunch start will be offset by the greater momentum resulting from a more elongated stance.

Physical Principles Applied to the Start

When a force F acts on a body of mass M for a duration of time T, the velocity of the mass will change from V_1 to V_2—stated formally as a physical law: $V_2 - V_1 = \frac{FT}{M}$. The mass of the runner in common engineering units will be in *slugs*, defined as body weight in pounds divided by the acceleration due to gravity (32 ft./sec.^{2}), resulting in ft./sec. velocity units. At the very beginning of the start, the mass M is at rest, hence V_1 is zero and vanishes from the equation. Since M is free to move forward, F will accelerate M during the entire period T that the runner is thrusting with force F with one or the other or both of his legs. If F is uneven, the term FT (called the ***impulse***) will consist of the sum of several sub-unit FT's. Since M is constant for any particular runner, his velocity as he clears the blocks will be determined only by how hard and how long he thrusts. Since we are concerned primarily with forward motion, F must be definied as the *forward* component due to the leg thrust. It must not include vertical thrust even though such a component may be necessary to get the runner in position for his first stride. While it is possible that it is important to good running, this aspect of the thrust does not contribute to forward motion off the blocks.

The total duration of thrust T is self-limited since the runner obviously cannot thrust after he leaves the blocks. However, when the subdivisions of FT contributed by the two legs are considered separately, it is evident that the rear-foot T can within limits be terminated prematurely and the front-foot T

can be initiated undesirably late in a poorly executed start. It would seem that in the *ideal* start from the blocks, both feet should start thrusting ***simultaneously*** and ***maximally***; as forward motion clears the straightened rear leg, that phase ends and the runner brings it forward to take the first stride, meanwhile continuing the maximal thrust with the front leg until it too has straightened and forward motion pulls it away from the block.

This being the sequence of events, it can be hypothesized that the duration of the rear foot impulse should be relatively independent of block spacing within wide limits, although with too extreme a spacing a shortened impulse will necessarily occur. On the other hand, the duration of the front-foot impulse should definitely be dependent on the longitudinal block spacing—the bunch start should give the shortest and the elongated start the longest duration. The maximum pressure during the thrust should increase on the rear block as the block spacing is lengthened, since there will be a tendency to separate the action of the two legs and complete the rear leg thrust before developing full force on the front leg; for this reason, the onset of the front leg thrust should be delayed with the longer block spacing. This tendency toward a separation of action should also tend to weaken the first phase of the front leg thrust with the elongated spacing, since the rear leg is in action at this time; furthermore, an increasing vertical component will slightly weaken the horizontal force available at longer block spacings, and the greater flexion of the front knee in the early phase of the impulse is a disadvantage. Except for the loss to vertical component, the peak thrust would remain unaltered because it occurs after the rear leg has completed its drive. Total impulse, which determines the velocity leaving the blocks, will probably increase with increasing block spacing because of the relatively large increase in impulse duration.

The effect of the momentum gained from the blocks should be evident in influencing the runner's speed for at least the first five or ten yards of a sprint; it may or may not carry through as a significant determiner of total dash time measured at fifty or a hundred yards. It should be pointed out that the above predictions from hypothesis in part represent qualitative patterns. While the velocity leaving the blocks can be calculated, it is not possible to give a numerical figure for estimated speed at five or ten yards. While it is possible to predict that some particular block spacing should be better than others that are shorter or longer, the available information does not offer a very satisfactory basis for specifying the optimal spacing.

Using the Dickinson data for starting time (with a blanket deduction of a tenth-second for reaction time) as a rough estimate of impulse duration T and the Kistler data on maximum foot force as an approximation of F, the impulse magnitude can be estimated. Assuming that the back foot duration was a third of the complete duration and that the average weight of the runners was 165 pounds, the velocity leaving the blocks may be calculated by the formula as 2.3 yds./sec. for the bunch start and 4.9 yds./sec. for the elongated start. Intermediate block spacings of approximately 16 and 21 inches yield velocities of 2.9 and 3.7 yds./sec. While these figures are probably too high, particularly for the larger spacings where the measured force at 45 degrees on the front foot

must have included a considerable vertical component, they are at least of the correct order of magnitude. It follows that the time lost from starting with the blocks in the medium or elongated position will be more than regained in the first few yards due to the greater block velocity as compared with the bunch start.

Apparatus

In order to investigate the problems raised in the above discussion, a special type of chronograph was constructed which automatically records the force-time graphs of the runner's pressure against the starting blocks. Since action and reaction are physically equal, such graphs afford a means of analyzing the dynamics of the start.

Each of the starting blocks consisted of a wooden face plate mounted on a metal carriage sliding on roller bearings on a metal base, so that only the horizontal component of the foot thrust was measured. As it moved backward in response to pressure, the sliding carriage pressed against a heavy coil spring in the horizontal plane. A rack and pinion attached to the carriage converted horizontal movement (resisted of course by the spring) into rotary movement which was conveyed by rods to the chronograph mounted several feet above the blocks. Another rack and pinion at the chronograph converted the rotation back into a horizontal movement magnified four-fold and recorded by a pen travelling sideways across the moving chronograph tape. The rack and pinion devices were carefully constructed so that they worked freely but had no lost motion. Adjustable slip-joints and universals on the rods made it possible to change the block spacings as desired. In a typical start, the rear-foot block plate moved $\frac{3}{8}$ inch from a force of 160 pounds, resulting in a pen movement of $1\frac{1}{2}$ inches; the front-foot plate moved $\frac{7}{32}$ inch from a force of 90 pounds, resulting in a pen movement of $\frac{7}{8}$ inch. Another pen actuated by an electromagnet recorded the starting signal and the instant the runner passed each of a series of timing stations placed at 5-yard intervals along the 50-yard experimental track. Reference time at intervals of 0.01 second was also automatically marked on the tape. With the tape moving at 3.4 in./sec., it was possible to measure the records with an accuracy of 0.005 second. Further details of the experimental track and the timer will be found in a previous report (4).

Subjects; Procedure

In an experiment of this type, the choice of subjects represents a compromise between (among other factors) the undesirable lack of skill of naive subjects and the undesirable tendency of highly experienced subjects to do best with the particular technique with which they are most experienced. In an effort to strike a proper balance, the sample used in the study included six men with two or more years of successful competitive college experience in the dashes, six with only freshman experience, and six with high school experience who had never run in college. Running ability, stated in terms of 50-yard sprint time, ranged from 5.75 to 6.75 seconds. It is of interest that the four men who ran

fastest in the present experiment included one whose experience was limited to one year of high school running and another who had had only junior college experience. All were upper division university students; their ages were not recorded. Weight and stature are shown in Table 1. Each man made four 50-yard runs, all on the same day, using toe-to-toe block spacings of 11, 16, 21, and 26 inches in a balanced order of presentation. Since there were 18 subjects, the total number of runs was 72. The testing was done with groups of two, permitting one man to rest while the other was running. A number of trial starts off the blocks with sprints to ten yards were made before each run, for warm-up purposes and to familiarize the runner with the particular block spacing that he was to use. Tennis shoes were worn—since the track had a granular black-top surface, there was little trouble with slippage. The framework holding the starting blocks and chronograph was varied in position as necessary so that each runner always started with his shoulders at the starting line.

TABLE 1

Body Size of the Eighteen Runners

Full leg length was computed as total height less sitting height; foreleg was measured from floor to top of bent knee while sitting).

	Weight (*pounds*)	Height (*inches*)	Full leg (*inches*)	Foreleg (*inches*)
Mean	166.3	70.1	33.8	21.9
σ	16.50	2.62	1.59	0.94
Range	145. to 197.	65.5 to 73.4	30.8 to 36.4	20.6 to 23.5

Experimental Results

The principal descriptive statistics are given in Table 2. They will be discussed briefly in the order that they appear, followed by a more extensive analysis of the data.

Reaction time. This was defined as the time elapsed between the starting signal and the first movement of response by the runner. Changes in block spacing did not influence the reaction time; the t ratios between successive block spacings are only 0.58, 1.40, and 0.78, and between the 11- and 26-inch spacings, 1.58. None of these is statistically significant.[1] The correlation between individual reaction times and 50 yard sprint times is $r = 0.18$, which is too small to be of significance, but is in close agreement with the finding of $r = 0.14$ reported in a recent study of 25 physical education major students (4). While the mean

[1] For these and subsequent calculations, the t ratio between blocks has been computed from the differences in individual scores for the two spacings being compared. In cases where the hypothesis stated in the introduction predicts a difference in a particular direction, the conventional standard of significance (5 per cent level of confidence) requires a t of 1.75 for 18 subjects and the highly significant standard (1 per cent level of confidence) requires a t of 2.56. Where the hypothesis does not predict the direction of the difference, the 5 per cent level requires t to be 2.11 and the 1 per cent level, 2.90. For brevity, t ratios or other statistical measures exceeding these respective limits will be termed "significant" and "highly significant."

TABLE 2

Statistical Summary of Leg Drive and Time Measurement
(Average σ in all tables is computed as a geometric mean)

Measurement	Block spacing									
	11 inch		16 inch		21 inch		26 inch		Average	
	M	σ	M	σ	M	σ	M	σ	M	σ
Reaction time (sec.)	0.125	0.022	0.120	0.023	0.113	0.009	0.116	0.016	0.118	0.0184
Duration of rear leg impulse (sec.)	0.163	0.037	0.166	0.031	0.165	0.032	0.156	0.035	0.163	0.0340
Lag of front leg (sec.)	0.033	0.016	0.041	0.017	0.044	0.016	0.048	0.021	0.041	0.0185
Duration of front leg impulse (sec.)	0.312	0.033	0.333	0.035	0.353	0.021	0.378	0.023	0.344	0.0283
Time on blocks (sec.)	0.345	—	0.374	—	0.397	—	0.426	—	0.385	—
Max. force rear leg (lb.)	112.4	32.1	129.3	36.4	133.3	33.8	125.8	38.3	125.2	35.20
Max. force front leg (lb.)	93.1	32.3	95.9	26.4	91.5	20.1	94.4	27.2	93.7	26.88
Block velocity (yds/sec.)	2.21	0.29	2.47	0.29	2.50	0.22	2.54	0.30	2.43	0.277
Net time 5 yds. (sec.)	1.241	—	1.236	—	1.226	—	1.224	—	1.232	—
Net time 10 yds. (sec.)	1.945	0.067	1.934	0.083	1.928	0.065	1.933	0.073	1.935	0.0722
Total time 50 yds. (sec.)	6.561	0.249	6.479	0.285	6.497	0.263	6.540	0.276	6.519	0.2691

reaction time of 0.118 seconds is faster than the 0.132 found in that study, the difference can be ascribed to sampling error since t is only 1.57. However, the present subjects ran the 50 yards significantly faster (difference = 0.26 seconds, t = 2.86).

Duration and Amount of Pressure on Starting Blocks. It may be seen in Table 2 that the duration of the rear leg impulse (which invariably begins before the front leg comes into action) does not change appreciably with increase of block spacing. While it does average 0.009 seconds less at 26 inches than at 21 inches, the difference is not statistically significant since t is only 1.51. The t's between other block spacings are all less than unity, ranging from 0.19 to 0.72. The anticipated delay in starting the front foot pressure is observed to occur, progressing regularly as the block spacing is increased, with a statistically significant difference (t = 2.52) between the shortest and longest spacings. Intermediate changes in spacing do not yield significant differences (t's for the successive differences are 1.65, 0.53 and 1.05). It should be mentioned that because the "delay" durations are very short, the error in measuring time is relatively large, about 12 per cent. The duration of the front foot impulse is also observed to increase regularly in the predicted direction as the block spacing is increased; the t's between successive changes in spacing are 2.58, 3.43 and 6.69, and between the 11- and 26-inch spacing, 13.17. All these differences are highly significant statistically. A statistical comparison of the complete time on the blocks is thought to be unnecessary since no theoretical issue is involved. It can be seen in the table that the total duration increases progressively with greater block spacing; for each spacing, almost exactly 89 per cent of the duration is due to the front foot impulse.

The maximum rear foot force increases with greater block spacing, but not as regularly as expected, and there is a theoretically unexplained tendency toward lessened force with the elongated stance. Between the 11- and 16-inch spacings the difference is highly significant (t = 2.70), but the other successive differences are non-significant (t's = 1.64 and 1.50). The front leg maximum force does not show a very regular trend. While there is no consistent statistical evidence of the predicted decreasing in force, it is true that the 21 inch stance is associated with a significant drop as compared with the 16 inch (t's = 0.65, 1.95, 1.18, the middle t being significant). It will be shown later that the early phase of the front leg impulse does seem to show a consistent trend.

Force—Time Curves; Velocity Leaving Blocks

Calculation of Impulse. Typical force-time curves traced from the chronograph records are shown in Figure I. It is apparent by inspection that many of these curves are so far from being rectangular that no dependable estimate of the starting impulse is possible by merely multiplying the maximum force and duration. The impulse was accordingly measured by determining the area of each individual curve on the original chronograph record with a polar planimeter. In effect, this procedure sums up all the sub-areas that have different instantaneous forces; it is an instrumental method of evaluating the *definite integral* of the force-time curve. Front and rear foot curves were of course measured

separately and the two added to secure the total impulse, which is equal to FT of the velocity equation given in the introduction. Knowing the weight of each man, it was a simple matter to calculate his velocity at the instant he cleared the starting blocks. Hereafter, total impulse magnitude will be stated in velocity units.

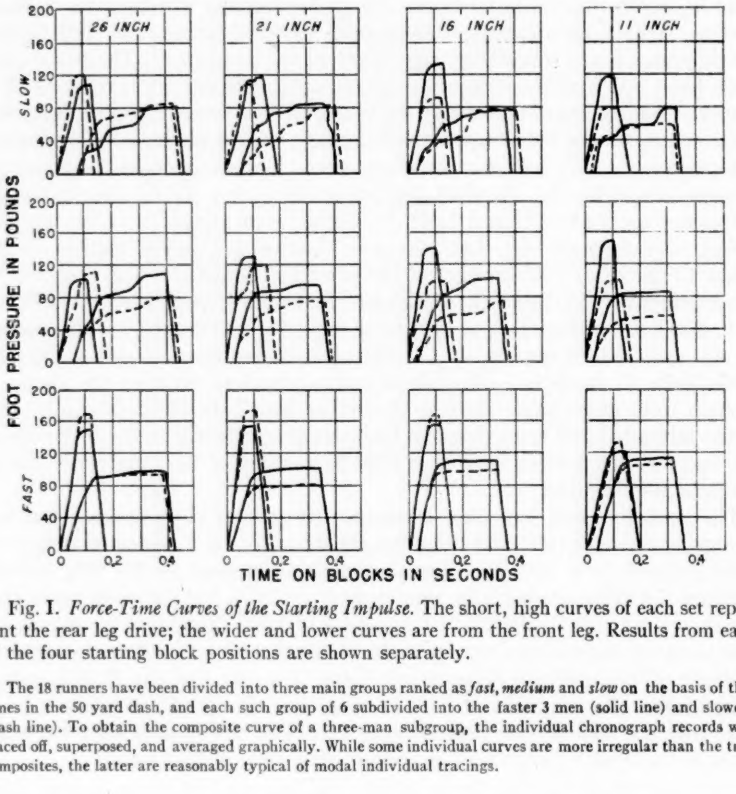

Fig. I. *Force-Time Curves of the Starting Impulse.* The short, high curves of each set represent the rear leg drive; the wider and lower curves are from the front leg. Results from each of the four starting block positions are shown separately.

The 18 runners have been divided into three main groups ranked as ***fast***, ***medium*** and ***slow*** on the basis of their times in the 50 yard dash, and each such group of 6 subdivided into the faster 3 men (solid line) and slower 3 (dash line). To obtain the composite curve of a three-man subgroup, the individual chronograph records were traced off, superposed, and averaged graphically. While some individual curves are more irregular than the triad composites, the latter are reasonably typical of modal individual tracings.

Block Velocity. Figure II shows curves based on all block spacings combined, for runners who were fast, medium or slow in reaching the 50-yard tape, and also for all subjects combined for each of the four block spacings. In this figure, the time and maximum thrusts have been drawn from exact measurements taken from the original records; the other aspects of the curves have been obtained by visual averaging of the curves of Figure I. While the form of these curves cannot be claimed to be exact, it is believed they offer a reasonably dependable description of the differences as related to skill and as resulting from lengthening the block spacing.

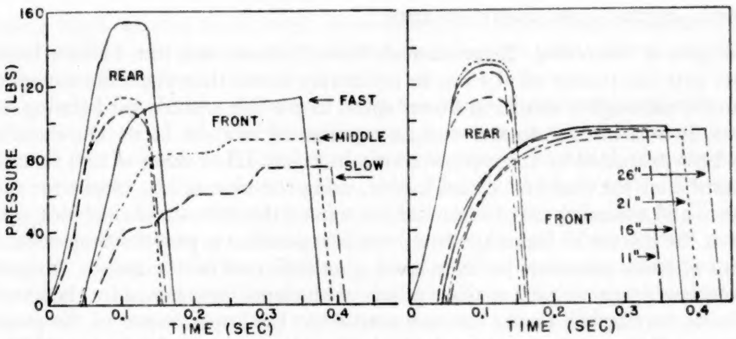

Fig. II. *Average Force-Time Curves* comparing the impulse characteristics of fast, medium and slow sprinters (left hand figure) and the influence of changing block spacing (right hand figure).

Relation of Sprinting Skill to Force-time Curves. For this comparison the runners have been separated into three groups of six men each, ranked on the basis of their 50-yard-dash scores. Each curve represents the average of four runs for each man. It can be seen in Figure II and in the more individualized curves of Figure I that the best sprinters are characterized by a very regular impulse. They apply the maximum front foot force early and maintain it throughout the whole period on the blocks. They also exert more force with each leg. The average block velocity of the fast sprinters is 2.75 yds./sec., compared with 2.30 for the medium and 2.24 for the slow group. A statistical evaluation shows that the difference in block velocity of the fast sprinters compared with either of the other two groups is highly significant, even though there are only six men in each group (t's = 3.20 and 3.64). The medium and slow groups do not differ significantly (t = 0.60). Since the fast group develops the leg thrust earlier and more forcefully, sprinters of this group tend to clear the blocks somewhat faster, as can be seen in the curves. Later on in the paper, the relation between individual starting block impulse and time in the sprint will be examined statistically.

Block Spacing. It can be seen in Table 2 that the block velocity increases progressively as the block spacing is lengthened. However, the differences for the 16–21 inch and 21–26 inch spacings are not significant (t's = 0.31 and 0.28). The ineffectiveness of the 11 inch bunch start is clear; the differences between it and the 16, 21 and 26 inch positions are highly significant (t's = 4.55, 4.42 and 4.35). Evidently at spacings ranging from 16 to 26 inches, the gain from greater impulse duration is almost completely balanced by loss of horizontal component force in the front leg drive, so the total impulse changes very little within this range. This influence of the block spacing can be observed in the curves of Figure I; it is less well shown in Figure II, where the early parts of the curves are somewhat conventionalized and over-smoothed.

BLOCK SPACING AND SPRINTING TIME

Region of Overtaking. Inspection of Table 2 shows that the 11-inch bunch start gets the runner off the blocks noticeably faster than the more elongated stances, although it results in slower speed to the five and ten yard timing stations. It is of interest to arrive at an explanation of these facts. The question has been examined by the method shown in Figure III. Taking as zero time the instant that the rear-foot thrust begins, using the time on the blocks for each stance and assuming that the runner has moved the distance of the block spacing at the instant he clears the front one, it is possible to plot the time-distance point of block clearance for each spacing as indicated on the graph. Tangents have been drawn at each of these points, with slopes determined by the known velocity leaving the blocks for each stance. At the upper corner of the graph, the time-distance relations have been obtained by extrapolating backward from the five yard and ten yard data, since a theoretical curve is available at these distances (4). In the figure, smooth curves have been drawn to agree with these

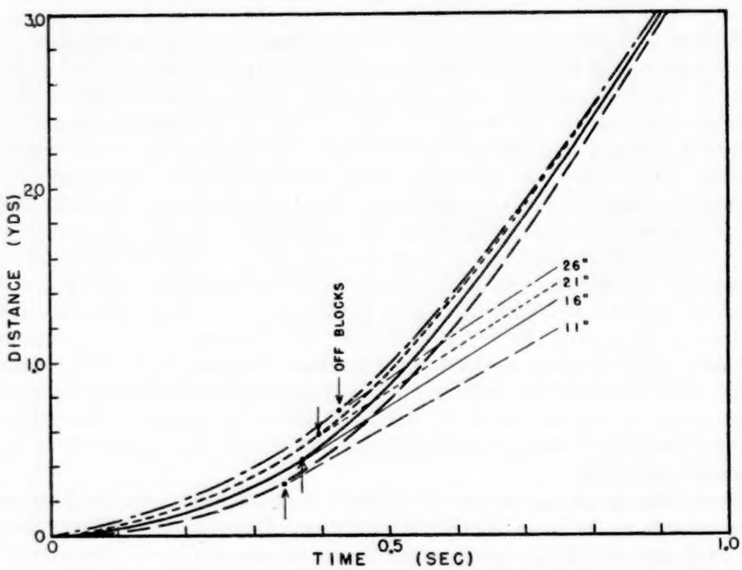

Fig. III. *Time—Distance Curves* for the first few yards of the sprint run.

several factors. Viewing the data in this manner, there is no need to postulate a region of overtaking; sprints from the 11-inch stance are actually slower from the very beginning. This holds true for any reasonable assumption regarding possible shifting of the center of gravity by each block spacing. While the elongated starts do require a longer time to clear the blocks (as indeed they must since there is further to go), there is no disadvantage involved. The sprinter's body is in motion during the extra period that he remains on the blocks; this period is being used profitably to impart greater velocity to his body. While too

great a block spacing must surely be undesirable, the available evidence indicates that 26 inches is not too large, although it does not seem to be appreciably better than 21 inches.

Results at Ten Yards. Compared with the 10 yard time attained with the bunch start, the 16, 21, and 26 inch spacings are associated with time advantages of 0.011, 0.017 and 0.012 seconds respectively. Although the absolute differences are small in all cases, the 11–16, 11–21 and 11–26 inch differences are highly significant statistically (t's = 3.01, 3.46 and 2.63). The 16–21 and 21–26 inch differences are not significant (t's = 0.48 and 0.54). At five yards the same pattern is evident (Table 2); no statistical evaluation was made at this distance, since it could be assumed that the closer proximity to the starting line would necessarily result in a greater influence of block velocity on the observed time scores.

Results at Fifty Yards. Because of the practical importance of knowing whether block spacing influences a typical sprint run, the total time between the starting signal and the finish tape was used in this comparison. With reference to the 11-inch bunch start, the 16, 21 and 26 inch spacings gave time advantages of 0.082, 0.064 and 0.021 seconds. The corresponding t's are 4.81, 4.47 and 1.51; the first two are highly significant. As can be seen in Table 2, the elongated or 26 inch stance gives poorer results than either of the two medium spacings; for the 16–26 inch comparison the difference is highly significant, although it is non-significant for the 21–26 inch data (in this case with the direction of the difference not predicted by hypothesis, the t for the 5 per cent criterion would be 2.11; the computed t was only 2.01). Between 16 and 21 inches, the difference is non-significant (t = 0.95).

As a check on these results, the individual data have been ranked and compared in Table 3. It can be seen that not a single sprinter made his best time

TABLE 3

Contingency Table Relating Starting Block Spacing to Rank Order of 50 Yard Speed

(Speed ranked I to IV in decreasing order of magnitude)

Block spacing	50 yard speed			
	I	II	III	IV
11 inch	0	3	4	11
16 inch	10	4	3	1
21 inch	7	4	7	0
26 inch	1	7	4	6

when using the bunch start, and the poorest run was most frequently made from that stance. Seventeen of the 18 best runs were made from a medium stance. The χ^2 calculated from this contingency table is 36.5, which is highly significant (with 9 degrees of freedom, a χ^2 of 21.7 is significant at the 1 per cent level).

In order to be sure that the outcome was not just a reflection of using a sample of sprinters of heterogenous experience, the scores of the six fastest runners were examined separately and found to exhibit the same relationship as was

observed in the total group. Five of the six had their best run off the 16 or 21 inch spacing and the other did best from the elongated stance. Five of the six made the poorest run with the bunch start; the other man did poorest with the elongated stance.

INDIVIDUAL DIFFERENCE IN STARTING IMPULSE

Relation between Impulse and Block Spacing. Since the increase in block spacing results on the average in increasing the force-time integral and thus the velocity off the blocks, it is important to discover the extent to which individual differences in the starting impulse are determined by the block spacing Table 4 is a contingency table illustrating that the relation is fairly high. The χ^2 computed from it is highly significant, 42.7, confirming the results obtained with the mean block velocities. A more detailed analysis reveals that among the six runners who had the fastest average 50-yard times, four obtained their best or second best impulse from the elongated start and two from a medium stance, which favors the elongated spacing somewhat more than the total group but is not greatly different.

By splitting Table 4 through the middle to combine the 11 with the 16 inch spacing and the 21 with the 26, also combining ranks I with II and III with IV,

TABLE 4

Rank Order of Starting Impulse Related to Starting Block Spacing

(Impulse ranked I to IV in decreasing magnitude)

Block spacing	Starting impulse			
	I	II	III	IV
11 inch	0	2	2	14
16 inch	3	6	8	1
21 inch	7	5	5	1
26 inch	8	5	3	2

TABLE 5

Relation Between Rank Order of Starting Impulse (force-time integral) and Rank Order of 50 Yard Speed

(Ranked I to IV in decreasing order of impulse or speed)

Starting impulse	50 yard speed			
	I	II	III	IV
I	9	1	5	3
II	4	11	2	1
III	4	5	6	3
IV	1	1	5	11

there is obtained a *2 by 2 contingency table* that yields a χ^2 of 10.9. From this the *phi coefficient* is computed as 0.389, which converts to $r = 0.61$. Thus there is a considerable positive correlaton between impulse and block spacing, but

considerable opportunity for individual differences in impulse magnitude to exist independently from the block spacing factor.

Impulse and Sprint Speed. Table 5 shows the relation between starting impulse and 50-yard sprint times. The χ^2 computed from this table is 36.9, which is highly significant statistically. As before, the six fastest runners show the same relationship between the variables as is found for the total group; in this comparison, a χ^2 was calculated for them separately and found to be 21.5, which is indicative of a somewhat higher relation since only 12.3 would have been expected with six cases when it is 36.9 for 18 men.

In order to examine the relation further, correlation coefficients (r) were computed between impulse and sprint time for each of the four block spacings and for both the 10-yard and 50-yard timing stations. As the additional work was small, intercorrelations were also computed for each variable between the different block spacings. These latter correlations represent lower limits of the test-retest reliability coefficients; the true reliability may be somewhat larger, particularly in the case of the starting impulse data where block spacing may influence different individuals unequally.

The results of the correlational analysis are given in Tables 6 and 7. Apparently there is a tendency for lower correlations in the runs made from the

TABLE 6

Correlations (r) Between Starting Impulse and Sprint Speed

Speed	Block spacing				
	11	16	21	26	Geometric average
Impulse *vs.* 10 yd	0.367	0.664	0.530	0.392	0.503
Impulse *vs.* 50 yd	0.301	0.537	0.596	0.416	0.476

TABLE 7

Intercorrelations (r) Between Blocks

Speed	Block spacing				
	11–16	16–21	21–26	11–26	Geometric average
Impulse	0.819	0.795	0.771	0.742	0.782
10 yard	0.850	0.758	0.850	0.743	0.802
50 yard	0.967	0.968	0.951	0.946	0.958

bunch start and higher correlations with one or the other of the medium stances; it cannot be determined if these differences are significant because the correlation between the correlations is not known. Probably the most dependable estimate of the relationships is given by the geometric average of the single coefficients, although it may well be that this procedure underestimates the relations for the optimum block spacing. (It may be noted that by conventional stand-

ards, $r = .468$ is statistically significant at the 5 per cent level.) Since there may be some interest in the rectilinearity of regression as well as the distributions of individual scores, scatter diagrams of the data have been prepared (Figure IV).

Both methods of analysis have agreed in establishing that sprinters who develop a strong start are on the average more likely to cross the finish tape sooner than weak starters, when block spacing is held constant. If we introduce variation in block spacing as well as individual ability to develop a strong start, there are indications that the relationship is higher. A *2 by 2 contingency table* relating best two runs to best two impulses on the four runs made by each man (a condensation of Table 5) yields a χ^2 of 10.9 and a *phi coefficient* of 0.389; this is the equivalent of $r = 0.61$.

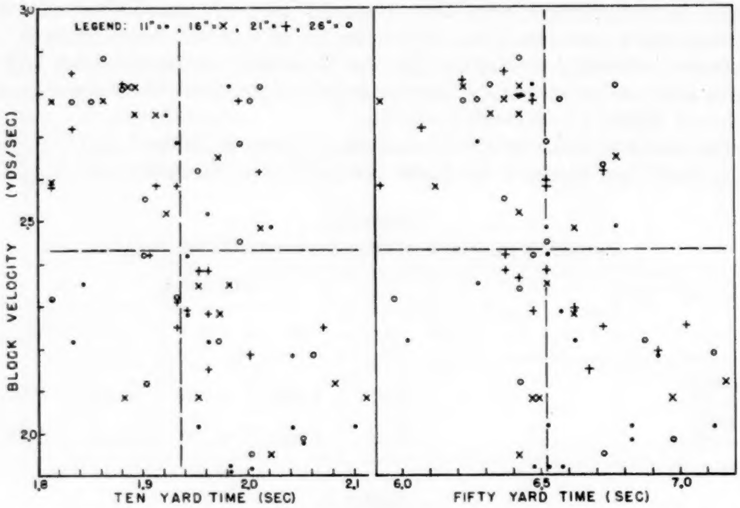

Fig. IV. *Scatter Diagrams* relating individual impulse magnitude (in units of block velocity) to 10 yard sprint time (left figure) and 50 yard sprint time (right figure).

LEG LENGTH AND BLOCK SPACING

In Table 1 it can be seen that the variation in leg length among the subjects is relatively small as compared with the experimental differences in block spacing. For this reason, it would be expected that the optimum spacing for any individual would strongly tend to be the same as the optimum for the average. Moreover, in the light of the evidence, the optimum region is broad rather than sharply defined. Nevertheless, since questions concerning leg length are sure to be raised, it seemed desirable to secure direct evidence. The analysis shown in Table 8 was accordingly undertaken.

Under the assumption that shorter block spacings should be relatively more effective with shorter legs, it would be expected that when the sprinters are

grouped according to leg length, there should be a tendency in this direction if the blocks need to be adjusted to the individual leg lengths. By studying Table 8 carefully, it can be seen that there is no indication whatever of any such tendency. Keeping in mind that a low average rank means fast sprint time, it is evident that the trend is in the opposite direction. Fore-leg length is found to correlate $r = 0.930$ with full leg length, indicating that there is no necessity to make a separate analysis for the fore-leg. No doubt the anticipated trend for short runners to do better with shorter block spacings could be observed if data from a very large number of sprinters were available, but it is clear that the need for individual block adjustment for different leg lengths is of no practical importance or it would have evidenced itself in the present sampling.

TABLE 8

Average Rank in the Sprints as a Function of Leg Length and Block Spacing

Leg length	11 inch		16 inch		21 inch		26 inch	
	10 yd.	50 yd.	10 yd.	50 yd.	10 yd.	50 yd.	10 yd.	50 yd.
Longest six	3.33	3.50	2.17	1.17	1.50	2.17	3.00	3.17
Medium six	3.33	3.33	2.00	1.50	2.50	2.17	2.17	3.00
Shortest six	3.67	3.50	2.83	2.50	2.00	1.67	1.50	2.33
Longest three	3.00	4.00	2.67	1.00	1.67	2.00	2.67	3.00
Shortest three	3.33	3.33	2.67	1.67	2.00	2.33	2.00	2.67

VARIANCE ANALYSIS

As a check on the other statistical treatments, the sprint data were subjected to a complex variance analysis. Net 50 yard time scores (i.e. with reaction time subtracted) were used. Since reaction time is not significantly related to sprint speed, its elimination removes one source of error variance. A summary of the results of the analysis is given in Table 9.

TABLE 9

Variance Analysis of Net 50 Yard Time Scores

Source of variance	DF	SS	Ratio	F
Between leg lengths	5	0.93	0.186/0.266	0.70
Individuals *within* leg lengths	12	3.19	MS = 0.266	—
Between block spacings	3	0.08	0.267/0.0221	12.08
Interaction, blocks by leg length	15	0.05	0.0033/0.0221	0.15
Interaction, blocks by individuals within leg lengths	36	0.76	MS = 0.0221	—

In agreement with the results of other treatments, it is found that block spacing is a highly significant determiner of sprint time ($F = 12.08$). The small "between leg length" variance ratio shows that leg length is not a significant contributor to sprint time ($F = 0.70$), while the even smaller ratio for "interaction between blocks and leg length" ($F = 0.15$) agrees with the rank order

comparison made earlier, confirming the conclusion that leg length is unrelated to the best block spacing.

Discussion

On the whole it would seem that the experimental results obtained confirm the theoretical position set forth in the introduction. As to agreement with other studies, the maximum leg force observed in the present experiment is definitely less than the figures obtained by Kistler. In part, the discrepancy can be explained by the elimination of the vertical component of the thrust; it is also probable that his subjects (all of whom were trained sprinters) were not comparable to those of the present study. The pattern of change he observed to result from shifting the block spacing is not inconsistent with the present findings.

The proportion of total force contributed by the front leg, 43 per cent, is less than the 51 per cent reported by Kistler. This difference is readily explained by the elimination of the vertical component in the present experiment. However, neither of these proportions do justice to the role of the front leg. Since it drives for a longer time, it makes a considerably larger contribution to the block velocity, namely 66.1 per cent when all stances and runners are averaged. For the fastest six sprinters the figure is 66.6 per cent, almost exactly the same.

Compared with the data of Dickinson, the present study agrees in finding that the sprinter spends a shorter time on the blocks when the spacing is short. On the other hand, there is definitely disagreement as to the time advantage at 2.5 yards he reported for the bunch start. Possibly his runners did better with that stance because they were accustomed to using it; they were highly experienced and coached on the bunch start.

On the practical side, it would seem that the medium stance offers a worthwhile advantage to the sprinter. While the absolute amount of time gained is not impressive, it is nevertheless true that the runners consistently made their best time from a medium stance and their poorest time from a bunch start. Since the advantage was evident at both 10 and 50 yards, it would be expected to hold for 100-yard sprints also.

Similarly, while the correlation between the individual starting impulse and sprint time is not high, it is significant and positive. The runners were fairly consistent in making their best time in the run that was started with their best block velocity, and for constant block spacing there was a definite relation between a good starting impulse and a fast sprint. This result suggests that it would be profitable to give attention in coaching to instructions designed to aid in achieving the ideal start. Knowledge of the nature of mistakes and of progress in correcting them is a powerful aid in learning. It was observed that the force-time graphs of several of the experienced sprinters showed room for considerable improvement. This is understandable; neither the coach nor the runner can discover very well from simple observation during the split-second occupied by the start, the time-pressure characteristics of each leg thrust. A simplified form of the apparatus used in the present investigation might be of value in this connection. Such a device might take the form of vertical levers, several feet long, supported by pivot bearings in a suitable heavy framework, with the

block and spring assemblies attached to the lower end of the levers to avoid the complicated sliding carriage. A thread attached to each lever could operate a kymograph stylus or other suitable recording apparatus.

Successful sprinting of course involves a great deal more than just a good start. It was pointed out in another paper (4) that a powerful leg drive appeared to be the most important factor in accelerating to the highest velocity. While no data are at hand to prove the point, it would seem that something more than powerful leg muscles is required—it is also a matter of coordinating the available leg force in the most effective way; of exerting the force at the right instant and for the correct length of time. While there are serious experimental difficulties to be overcome, it should nevertheless be possible to analyze the striding phase of the sprint and discover the ideal form for greatest speed.

Summary and Conclusions

A theoretical description of the "ideal" start, and the influence of foot placement upon its effectiveness, was derived from physical considerations. To test the hypothesis, a pressure-recording chronograph was mechanically connected to the starting blocks. Force-time graphs of the leg thrust during the start were obtained on 18 sprinters who made four runs each, using longitudinal toe-to-toe spacings of 11, 16, 21 and 26 inches to vary their starting stance. Times were recorded automatically for the starting signal, the first movement in response, and the instant of passing markers placed 5, 10 and 50 yards distant from the starting line. The area of each graph was measured, making it possible to calculate the effectiveness of the individual starts in terms of the runner's velocity at the instant of clearing the last block on the basis of a standard physical formula. Statistical analysis of the data leads to the following conclusions:

1. Reaction time is uninfluenced by block spacing and uncorrelated with speed in the sprints.
2. Leg length is not important in determining the best block spacing and is unrelated to 50 yard sprinting ability.
3. Use of the 11 inch bunch start results in clearing the blocks sooner but with less velocity than secured from medium stances, resulting in significantly slower time at 10 and 50 yards.
4. The highest proportion of best runs and the smallest proportion of poorest runs result from starting with a 16 inch stance. A 21 inch stance is nearly as good.
5. An elongated stance of 26 inches results in greater velocity leaving the blocks, but the advantage is lost within the first ten yards.
6. With block spacing held constant, speed in the sprint is significantly related to how closely the individual approaches the ideal start (defined as early development and maintenance of full maximal thrust with each leg until the respective blocks are cleared as a necessary result of forward motion).
7. Although the rear leg develops considerably more maximum force than the front, the latter contributes twice as much to the block velocity because its impulse has a longer duration.

8. The experimental results are, in general, consistent with theoretical expectations and apply to sprinters differing in ability and skill.

9. A simplified form of the pressure-chronograph will probably prove useful in teaching sprinting skill.

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Health Problems of Interest to College Men

James H. Humphrey

Michigan State College
East Lansing, Michigan

Since Harvard University began many years ago with the presentation of six lectures to young men on "what they should know about the human body" (2), there have been many and varied conceptions as to what should be taught on the college level in the area of health and hygiene.

These early lectures were typical of the instructor-dominated type of teaching which was to prevail for some decades to come. As educators gradually became aware that there was reason to base course content on students' needs and interests, a change began to take place. Although the change has been slow in coming about, we are coming to the realization of the fact that the students' needs and interests should be more carefully identified, and that they should be given more opportunities to share in the planning of courses which concern their health. Oberteuffer (4), a pioneer in this area, was probably one of the first to make a study regarding health problems of college students. Recent studies by Kitzinger (3) and Boyd (1) accentuate the possibilities in this area and indicate the need for further investigation.

Purpose of the Study

The purpose of this study was to determine the health problems of interest to a group of 60 Sophomore men enrolled in a Personal and Community Hygiene course.

Method of Procedure

In order to determine their health problems of interest, 60 men enrolled in a course in Personal and Community Hygiene were asked to write down three of the problems which they felt they would like most to discuss in this particular course.[1] After the men had engaged in this free-writing technique in determining problems of interest, there evolved 20 classifications of various health problems of interest. This material resulting from the free response technique was developed into a check list and submitted to the class as a means of further determining their health interests.

Presentation of the Data

The problems of interest are presented in tabular form. Table 1 indicates the rank order of the problems of interest derived from the free-writing technique.

[1] Course taught by the writer at Boston University School of Education, first semester, 1950–51.

TABLE 1

Health Problems of Interest to College Men Indicated by Free Writing Technique Showing the Number of Times a Problem Was Mentioned and the Percentage of Students Indicating an Interest

Problem of interest	Number	Per cent
Nutrition and Foods	38	63.3
Communicable Diseases	23	38.3
Exercise, Sleep, Rest	21	35
Sex Education	21	35
Narcotics and Stimulants	16	26.6
Mental Hygiene	11	18.3
Home Hygiene	9	15
Responsibility in Community Hygiene	8	13.3
Cancer	6	10
Heart Disease	6	10
Posture	4	6.6
Physical and Dental Examinations	3	5
Care of Sense Organs	3	5
Skin Disease	3	5
Clothing	3	5
Treatment of Injuries	1	1.6
Socialized Medicine	1	1.6
Care of Hair	1	1.6
Sanitation	1	1.6
Elimination	1	1.6

TABLE 2

Health Problems of Interest to College Men Indicated by a Check List Constructed from Free Responses of Same Group Showing the Number of Times a Problem Was Checked and the Percentage of Students Indicating an Interest

Problem of interest	Number	Per cent
Sex Education	31	51.6
Communicable Diseases	28	46.6
Nutrition and Foods	23	38.3
Care of Sense Organs	12	20
Home Hygiene	10	16.6
Exercise, Sleep, Rest	9	15
Heart Disease	7	11.6
Treatment of Injuries	7	11.6
Sanitation	7	11.6
Mental Hygiene	7	11.6
Responsibility in Community Hygiene	6	10
Posture	5	8.3
Skin Disease	5	8.3
Cancer	4	6.6
Care of Hair	4	6.6
Elimination	4	6.6
Narcotics and Stimulants	4	6.6
Physical and Dental Examinations	4	6.6
Clothing	1	1.6
Socialized Medicine	1	1.6

Table 2 indicates the rank order of the problems of interest derived from the check list which was constructed from the problems derived from the free-writing technique.

It is interesting to note some of the changes which occurred in the two techniques used for determining health problems of interest. In order to determine the degree of relationship between the two techniques, that is, free writing and check list derived from free writing, a rank difference correlation was computed. This resulted in a rank order coefficient of .675 between the free writing and the check list derived from free writing.

Summary and Conclusions

Sixty men enrolled in a course in Personal and Community Hygiene were asked to indicate their health problems of interest by writing down the three health problems of greatest interest to them. This material was developed into a check list and submitted to the men as a further means of determining their health problems of interest.

Although there would perhaps be little difference in the problems of interest selected by the students and the topics selected by the instructor for presentation in the course, there might be a great deal of difference in importance of problems as far as students are concerned. For this reason it might be well for the instructor in college hygiene to attempt to find out from students just what their interests are. In this way the instructor could divide his time wisely on each of the topics and keep the course in harmony with the tone of the class.

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The Construction of a Field Hockey Test for Women Physical Education Majors

ELLEN DAVIS KELLY

University of Oklahoma
Norman, Oklahoma

AND

JANE E. BROWN

THE PRESENT research was prompted by the need for a written knowledge test covering all areas of competence desired of teachers of field hockey. Examination of the literature revealed three tests (9, 10, 14) none of which covered current practices in all of these areas.

Curricular Validity

Eleven texts (1, 2, 3, 4, 5, 6, 7, 11, 12, 13, 16) were examined and analyzed for major areas of competence deemed necessary for the woman teacher and/or coach of field hockey. Four major areas—rules, techniques, coaching procedures, and umpiring—were determined with 19 to 23 subdivisions under each. These sub-topics were arbitrarily weighted from 1 to 5 in the order of increasing importance and complexity. (See left-hand column, Table 1.)

Construction of Test Items

The five-response type question was selected as offering best adaptability to the subject matter, as well as being preferred by most authorities on construction of objective tests. The construction of the test included three stages: the initial test, the pre-test, and the revised test, the latter being a refinement of the former two.

The *initial test* items were constructed to cover the various topics of the four major areas in proportions called for by the weighting assigned to each topic. Nine objective tests, including seven submitted by various college departments of physical education, were available for reference. A total of 103 multiple response items were constructed. The resulting 515 response choices were tallied against the desired curricular emphasis. (See right-hand column, Table 1.) This test was submitted to seven nationally known players, coaches and/or umpires of field hockey for review and suggestions with regard to question construction and scope of the test.

The *pre-test* was developed as a revision of the initial test. It consisted of 116 items; 28 on rules, 28 on techniques, 32 on coaching procedures, and 28 on umpiring. This test was administered to a group of 30 subjects with a wide range of experience in field hockey: 4 nationally recognized experts, 4 physical education instructors of field hockey, 18 physical education majors with one

TABLE 1

Topic Content within the Four Areas of Field Hockey Showing Relative Weighting and Frequency of Tallied Response Choices

Weighting	Topics	Tallied response choices	Weighting	Topics	Tallied response choices
	Rules			*Coaching Procedures*	
5	Fouls	31	5	Knowledge of positions	63
4	Out-of-bounds	18	5	Defense tactics	50
3	Corners	14	5	Goalkeeping	25
3	Game interference	12	5	Attack tactics	25
3	Penalty bully	11	4	Receiving ball	15
3	Roll-in	11	4	Tackling	15
3	Playing time	11	3	Covering	13
3	Free-hit	10	3	Passing ball	12
2	Time-out	9	3	Roll-in	10
2	Penalty corners	8	3	Coaching suggestions	10
2	Accidents in game	7	3	Bully	10
2	Bully	7	2	Marking	8
2	Number of players	5	2	Interchanging	7
2	Goal	5	2	Free-hit	5
2	Penalties	5	2	Dodging	5
2	Dimensions	5	1	Fielding	4
1	Substitutions	4	1	Backing-up	2
1	Captain's duties	2	1	Clearing	2
1	Delaying the game	1	1	Drawing a player	1
	Techniques			*Umpiring*	
4	Knowledge of techniques according to position	20	5	Position of umpire	32
			3	Free-hit	13
3	Marking	10	3	Corners	13
3	Straight tackle	10	3	Penalty bully	12
3	Left-hand lunge	10	3	Penalty corners	11
2	Circular tackle	9	3	Bully	11
2	Scoop dodge	9	3	Substitutions	11
2	Fielding	9	3	Procedures of game	11
2	Drive	7	3	Hold whistle	10
2	Right cut	7	3	Offside	10
2	Right-hand lunge	6	2	Obstruction	7
2	Flick	6	2	Dangerous hitting	6
2	Bully	5	2	Advancing	6
2	Goalkeeping	5	2	Sticks	5
2	Receiving a pass	5	2	Roll-in	5
2	Non-stick dodge	5	2	Goal scored	5
2	Push pass	5	2	Accidents	5
2	Dribble	5	2	Wrong decision	5
1	Left job	4	2	Blow whistle	5
1	Right job	3	1	Umpire relations	3
1	Pull-to-dodge	3	1	Timekeepers and scorekeepers	2
1	Reverse sticks	2	1	Arm signals	1
1	Right drive	2			

or more seasons of field hockey experience, and 4 Freshman physical education majors with no hockey experience. In addition to answering the questions, subjects were asked to include in marginal notes any confusions which they recognized and their suggestions for improvements.

The *revised test* was developed on the basis of suggestions made by subjects taking the pre-test, and on the basis of an item analysis of the 30 pre-test

answer sheets. Nonfunctional items were detected, degree of difficulty of each item was computed, and an estimate was made of the degree of discrimination of each item. The revised test included 106 items: 27 on rules, 26 on techniques, 30 on coaching and 23 on umpiring.

Administration of the Revised Test

A total of 209 subjects was selected to conform to 4 divisions of experience in field hockey: 12 nationally recognized players, coaches, and/or umpires (hereafter called the expert group), 158 physical education majors who had completed one or more semesters of theory and practice in field hockey at one of six different colleges (hereafter called the major group), 20 non-major students who had completed one or more seasons of field hockey (hereafter called the service group) and 17 Freshman non-majors who had never had any experience in field hockey (hereafter called the lay group).

Standardized directions for administering the test were sent to the six colleges participating in the research. Separate answer sheets were provided. Scoring was done by a superimposed punched hole type key. The number of errors was totalled as the subject's score, rather than the number correct, in order to eliminate subtraction from the total number of questions, and hence a possible source of error.

Two types of supplementary information were obtained for use in validating the test: (1) On an individual experience rating sheet each major student indicated her seasons of experience in high school, college, and with hockey clubs, together with the approximate length of the season, number of practice periods per week, calibre of participation and teaching experience. (Table 2.)

TABLE 2
Supplementary Information

	Number of days per week	Number of weeks per season	Number of seasons	Weighting
1. Field hockey in high school				
Played field hockey in Physical Education Class........				1
Played intramural field hockey....................				2
Played varsity field hockey........................				3
2. Field hockey in college				
Played field hockey in Physical Education Class (majors)				3
Played intramural field hockey....................				2
Played varsity field hockey........................				3
3. Taught field hockey..............................				
High school..................................				2
College service program........................				2
College major program.........................				3
Club field hockey..............................				3
4. Played field hockey with a club......................				2

Name of last club affiliation................Association................

(2) Each major student was rated subjectively by her instructor as to anticipated field hockey teaching competence in a high school situation, not playing ability primarily.

Evaluation of the Revised Test

Item Analysis. Statistical validity was appraised by an item analysis including degree of difficulty of items, Flanagan Index of Discrimination, and the per cent of functioning of each response choice. (Table 3.) Degree of difficulty ranged from 5–100 per cent correct responses with a mean of 59 per cent correct and a standard deviation of 17 per cent. Only four items had degrees of difficulty beyond the 10–90 per cent deemed desirable. Flanagan Indices of Discrimination ranged from −.23 to .63 with a mean index of .35 and a standard deviation of .16. Eighteen items had indices below the acceptable minimum of .20. If these items were to be excluded from the test the mean Flanagan Index would be .40 (Table 4) and the curricular validity of the test would not be materially disturbed. (Table 5.)

TABLE 3

Comparison of Ranges, Means, and Standard Deviations of the Discriminating Ratings and Non-functioning Responses for the Four Parts of the Revised Test

Test Areas	Degree of difficulty			Discrimination index			Non-functioning responses	
	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean
Rules	.26–1.00	.60	.17	0–.63	.37	.16	0–4	.59
Techniques	.22– .90	.66	.16	.05–.63	.37	.16	0–2	.92
Coaching procedures	.05– .96	.59	.20	−.23–.60	.29	.16	0–3	.70
Umpiring	.17– .82	.49	.18	.01–.63	.37	.16	0–2	.61
Total parts (106 items)	.05–1.00	.59	.19	−.23–.63	.35	.16	0–4	.70

TABLE 4

Comparisons of Ranges, Means and Standard Deviations of the Discriminating Ratings and Non-functioning Responses for the Four Parts of the Revised Test Eliminating the Eighteen Non-discriminating Items

Test Areas	Degree of difficulty			Discrimination index			Non-functioning responses	
	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean
Rules	.26–.81	.59	.15	.24–.60	.41	.12	0–2	.48
Techniques	.22–.87	.66	.14	.22–.63	.42	.12	0–2	.90
Coaching procedures	.27–.87	.64	.19	.20–.60	.35	.10	0–3	.79
Umpiring	.17–.82	.52	.17	.21–.63	.41	.12	0–2	.65
Total test minus the 18 non-discriminatory items	.22–.87	.60	.17	.20–.63	.40	.12	0–3	.70

TABLE 5

Topic Content within the Four Areas of Field Hockey Showing Relative Weighting and Frequency of Tallied Response Choices After the Deletion of the Eighteen Items of Poor Discrimination

Weighting	Topics	Tallied response choices	Weighting	Topics	Tallied response choices
	Rules			*Coaching Procedures*	
5	Fouls	31	5	Knowledge of positions	51
4	Out-of-bounds	17	5	Defense tactics	42
3	Corners	14	5	Goalkeeping	20
3	Game Interference	12	5	Attack tactics	19
3	Penalty bully	11	4	Receiving ball	15
3	Roll-in	10	4	Tackling	15
3	Playing time	6	3	Covering	12
3	Free hit	7	3	Passing ball	12
2	Time-out	9	3	Roll-in	6
2	Penalty corners	7	3	Coaching suggestions	10
2	Accidents in game	7	3	Bully	10
2	Bully	5	2	Marking	7
2	Number of players	0	2	Interchanging	6
2	Goal	5	2	Free-hit	5
2	Penalties	5	2	Dodging	5
2	Dimensions	5	1	Fielding	3
1	Substitutions	4	1	Backing-up	1
1	Captain's duties	2	1	Clearing	2
1	Delaying the game	1	1	Drawing a player	1
	Techniques			*Umpiring*	
4	Knowledge of techniques according to positions	19	5	Position of umpire	31
			3	Free-hit	13
3	Marking	10	3	Corners	11
3	Straight tackle	8	3	Penalty bully	10
3	Left-hand lunge	8	3	Penalty corners	9
2	Circular tackle	7	3	Bully	10
2	Scoop dodge	7	3	Substitutions	11
2	Fielding	3	3	Procedures of game	11
2	Drive	7	3	Hold whistle	9
2	Right cut	6	3	Offside	10
2	Right-hand lunge	6	2	Obstruction	7
2	Flick	5	2	Dangerous hitting	6
2	Bully	5	2	Advancing	6
2	Goalkeeping	5	2	Sticks	5
2	Receiving a pass	5	2	Roll-in	5
2	Non-stick dodge	5	2	Goal scored	5
2	Push pass	4	2	Accidents	5
2	Dribble	3	2	Wrong decisions	5
1	Left job	3	2	Blow whistle	5
1	Right job	2	1	Umpire relations	3
1	Pull-to-dodge	3	1	Timekeepers and scorekeeper	1
1	Reverse sticks	1	1	Arm signals	0
1	Right drive	1			

Response choices were considered non-functioning if not selected as the correct response by at least 2 per cent of the subjects. There were 74 responses or an average of less than one non-functioning item in each question. However, since many responses included the possibility of more than one response containing correct items (for example "all of the above are correct," "none of the above is correct," "two but not three of the above are correct," etc.) it is inevitable that many of the responses not actually checked were seriously

considered by the subjects and therefore were actually functioning in final selection of the one thought to be most correct.

Validity. The procedures previously described were accepted as evidence of satisfactory curricular validity. Three further approaches to the problem of validity were made: (1) comparison of scores of experts, majors, service, and lay subjects, (2) correlation of test scores with extent of field hockey experience, and (3) correlation of test scores with instructor's rating of major student's competence to teach field hockey.

An examination of Table 6 shows a progressive increase in the number of wrong responses through the expert, major, service and lay groups, with critical ratios in all cases significant and in four cases very large. If the basic assumption is accepted—that these four groups were so selected as to represent real difference in field hockey experience and competence—these data offer evidence of definite test validity.

TABLE 6

Comparisons of Variability and Reliability Among the Four Groups Tested

Basis	Experts	Majors	Service	Lay
Number of subjects	12	158	22	17
Range of errors	10–26	12–76	45–82	73–90
Mean number of errors	15.33	44.84	65.05	81.12
Standard deviation	4.57	12.50	11.40	4.07
Standard error of the mean	1.38	1.00	2.49	1.02
Standard error of the difference				
a) Experts		1.70	2.84	1.71
b) Majors			2.68	1.42
c) Service				2.69
d) Lay				
Critical ratio				
a) Experts		17.36	17.51	38.47
b) Majors			7.54	25.55
c) Service				5.97
d) Lay				

Experience data were obtained by subjects' responses to the questionnaire. The quality of the various types of experience was scored by an arbitrary weighting as shown in the righthand column of Table 2. Each subject was thus given a numerical experience score consisting of the sum of the (number of days per week) $\times$ (number of weeks per season) $\times$ (number of seasons) $\times$ weighting. The Pearson product moment correlation between standing on the written test and extent of experience was .60 for the combined expert and major groups and .52 for the major group alone. These correlations may be considered rather significant, since obviously there are many factors contributing to field hockey comprehension which cannot be measured by years of experience.

The Pearson product moment correlation between instructor's rating of the student's probable teaching competence and her standing on the written test was .64 for the major group. This correlation also may be considered

significant since the criterion of teaching competence obviously includes many factors not measured by a written test.

Reliability. Correlations of the scores on the odd-numbered and even-numbered items were computed and corrected to actual test length by use of the Spearman Brown prophecy formula. For the 209 subjects including expert, major, service and lay subjects the coefficient was .89 corrected to .94. For the major group only, in which the number of subjects was reduced by one fourth and the range of scores also reduced by one fourth, the correlation was .79 corrected to .88. The test thus meets the reliability standard recommended by Symonds for 100 item 5 choice multiple response type tests (15).

Summary and Conclusions

1. This study reports the construction and validation of an objective written examination on field hockey, designed for use with physical education major women who are prospective teachers, coaches and umpires of field hockey.
2. An objective 106-item, five-response type test[1] was administered to 209 subjects with a wide range of field hockey experience, including nationally recognized experts, physical education major students, non-major college students with field hockey experience, and college women with no field hockey experience.
3. A comparison of mean scores showed the test to be increasingly difficult through expert, major, service and lay groups. Critical ratios of the difference between means ranged from 5.97 to 38.47.
4. A validity coefficient of .60 was found between the test standing of the combined expert and major groups and extent and quality of field hockey participation. For the major group only, the correlation was .52.
5. A validity correlation of .64 was found between test standing and major student's competence to teach field hockey as rated by their instructors.
6. The reliability coefficient for the total group was .94 and for the major group .88.
7. Correct responses to each of the test items ranged from 10 to 90%, with a mean difficulty of 59%.
8. Nonfunctioning responses averaged .70 or less than one per test item.
9. The discriminatory power of the test as a whole was adequate as evidenced by an average Flanagan Index of .35. Eighteen items yielded indices below the acceptable minimum of .20.
10. Deletion of the 18 items of poor discrimination raised the discriminatory index of the test as a whole to .40 and did not materially disturb the curricular validity of the test. This resulting 88-item test would constitute a reliable and valid test.

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[1] A copy of the test question may be obtained from Ellen Kelly, Department of Physical Education for Women, University of Oklahoma, Norman, Oklahoma.

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Health Interests of 10,000 Secondary School Students

Joseph E. Lantagne

University of California
Santa Barbara, California

The inclusion of health instruction in the curriculum and the importance of interests in learning have been well established. Today health is implied in each of the principles of education as outlined by the Education Policies Commission.[1] The President's Commission on Higher Education has also accepted health education as a major function of the college or the university. The American Association of School Administrators in the 1952 Yearbook, *Health in Schools*, states the following: "The course of study needs to be carefully planned to avoid duplication and to meet the needs, interests, and capacities of the particular group."[2]

This study is to concern itself with the determination of health interests of secondary school students as a basis for the improvement of the school curriculum in health. Interest is defined to be "the conscious feeling of concernment in an object, regarded especially as a stimulant and guide to the arousement and direction of attention."[3]

Related Studies

One of the first studies concerning health interests was the compilation of lists of incentives and interests under the directorship of Clair E. Turner[4] in 1929.

Delbert Oberteuffer[5] made an extensive study of health interests as an integral part in the development of a personal hygiene course for college students. In 1935 Rooks[6] discovered a wide range of interest in the items in his personal hygiene questionnaire given to 639 freshman and sophomore men. In 1947 the Denver Public Schools[7] conducted a study of health interests

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[1] Education Policies Commission, *The Purposes of Education in American Democracy*. Washington, D. C.: National Education Association, 1948, p. 47ff.

[2] American Association of School Administrators, Twentieth Yearbook, *Health in Schools*. Washington, D. C.: American Association of School Administrators, 1952. p. 75.

[3] Funk & Wagnalls, *New "Standard" Dictionary of the English Language*. New York and London: Funk & Wagnalls Co., 1947, p. 1279.

[4] C. E. Turner, Incentives and Interest in Health, *Journal of Education*, Vol. CX. No. 2 (July 8, 1929), p. 274.

[5] Delbert Oberteuffer, *Personal Hygiene for College Students*. New York, Teachers College, Columbia University, 1930.

[6] Roland Rooks, The College Freshmen's Knowledge of and Interest in Personal Hygiene, *University of Iowa Studies: Physical Education, No. 2, Research Quarterly Supplement*, VI: 3, (October 1935), pp. 73–74.

[7] *Health Interests of Children*. Denver: Denver Public Schools, 1947, p. 1.

through parents, teachers, and pupils with the results to be a guide to better preparation of the health curriculum for their schools.

A recent study was conducted by Mary Cooke Jessop[8] using an inventory substantially the same as the one used by this author. Jessop's study of interests indicated these secondary school students were interested in all aspects of health education in some degree, although there is a great variance in degree of interest.

Procedure

The health inventory used in this study was compiled by O. E. Byrd, M.D., professor and director of the Department of Hygiene, School of Education, Stanford University. The inventory consisted of 300 items under major classifications as outlined by O. E. Byrd in *The Research Quarterly*, 1950.[9] This inventory was the result of Dr. Byrd's selecting items from over 10,000 articles appearing in scientific journals since 1942. These items were revised several times after experimentation at Stanford University and again after use by Mary Cooke Jessop on the secondary level.

Participating in this study were 10,000 students from 26 high schools of 10 different states: California, Georgia, Florida, Indiana, Maine, Maryland, Massachusetts, New York, Ohio, and Wisconsin. The schools were situated in both heavily populated centers and in rural areas so that the students participating in this study represented a reasonable cross section of the high school population of the United States.

In each of these schools there were one or more persons with a high interest in health education who were responsible for coordinating and administering the inventories. A specifically designated period of time was assigned and the inventories were taken anonymously in order to enlist the best efforts of the students. Exceptions to this occurred in three classes, each in a different school, in which the identification of inventories was made in order that retests could be correlated with the originals. In all instances the cooperation of the students and the faculty members was excellent.

To simplify computations in this study, only 10,000 cases were used although additional inventories were answered. Inventories that were incomplete in the basic materials were first eliminated. By basic material is meant age, sex, and year in school. The remaining cases were eliminated at random proportional to the number of cases from each school.

This study was started in 1947 and completed in 1951. A study of 3,000 secondary school students of California,[10] incorporated in the present study, was completed in 1948.

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[8] Mary Cooke Jessop, *Health Interests of High School Students*, Unpublished thesis, Stanford University, 1948, pp. 76–77.

[9] O. E. Byrd, "Health Problems of Significance for Course and Curriculum Construction," *The Research Quarterly*, **21:** 1, (March 1950), pp. 1–10.

[10] Joseph E. Lantagne, *An Analysis of Health Interests of 3,000 Secondary School Students of California*, Unpublished dissertation, Stanford University, 1948.

Analysis of the Data

Immediately following the gathering of the completed inventories, the information was transferred to International Business Machine scoring cards. Upon completion of the transfer the cards were segregated according to: first, religion; second, grade in school; and third, sex.

The item "Have you had a course in hygiene in high school?" was omitted from the computations. Of the students surveyed only about 10 per cent had had a specific course in health education. Although most schools offered some health instruction in their curriculum through correlated courses, it was the feeling of the author that this type of instruction did not constitute a course devoted primarily to health.

Originally the cards were segregated according to religion, age, sex, and year in school. However, after analysis of data of 3,000 cases according to these factors, it was decided that religion, age, and year in school played insignificant roles in ascertaining health interests. Finally, it was decided that cards were to be sorted into two major categories: boys and girls.

An analysis of all items was made, and items were placed in rank order from greatest interest to least interest. These rankings are shown in Table 3. The next step was to compute student interest according to the major health areas, and this information is summarized in Table 1.

In order to realize full utilization of the results of this inventory, the items of greatest interest were organized in lists according to sex. This gave comparative results that might easily be translated into parts of a curriculum in health education.

TABLE 1

Interests of 10,000 Secondary School Students by Major Health Areas

Order	Major Area	Items in area	Total response	Percentage interested
1	Habit Forming Substances	9	35,437	39.4
2	Safety	17	65,826	38.7
3	Family Health	23	83,974	36.5
4	Mental Health	14	44,637	31.4
5	Exercise and Body Mechanics	12	37,476	31.2
6	Health as a Social Problem	9	27,902	31.0
7	Care of Special Organs	19	57,999	30.5
8	Health and the Physical Environment	24	67,546	28.1
9	Health as a Social Accomplishment	9	23,961	26.6
10	Chronic and Degenerative Disorders	9	23,824	26.5
11	Fatigue and Rest	14	36,916	26.4
12	Nutrition and Health	16	39,277	24.5
13	Infection and Immunity	25	61,016	24.4
14	School Health	18	41,941	23.3
15	Heredity and Eugenics	10	22,026	22.0
16	Community Health	15	29,518	19.7
17	Excretion and Health	12	22,891	19.1
18	Health Services and Facilities	16	30,205	18.9
19	Occupational Health	16	28,708	17.9
20	Trends and Possibilities	7	12,125	17.3
21	International Health	6	9,067	15.0

Validity and Reliability

Validity was established in the following two ways:

1. The significance of the health problems listed was established by selection from 10,000 health articles in leading medical and public health journals. Frequent discussions of health problems in these professional journals would appear to establish these problems as significant ones.

2. The inventory was administered to a group of high school students on a trial basis which eliminated overly technical terms and other confusing factors.

Reliability was established as follows:

1. The study of 3,000 California secondary school students correlated .70 and .74 with Jessop's 640 secondary school students. Jessop used a similar, preliminary, and nearly identical form of the health inventory. (Byrd's original material.)

2. Correlations of .87 occurred between test and retest with one school group; .91 between test and retest with another school group; and .92 with a third retest group. These tests were taken by students included in the study of 3,000 California secondary school students.

3. A reliability of .91 was computed by the split-half method on 200 inventories.

4. The study of 3,000 California secondary school students correlated .94 with a study of 1,000 junior college students conducted by the author.

5. The interests in major health areas by each geographical location was compared to the interests in major health areas of the entire study. A comparison of the East with the entire study resulted in a correlation of .87; Midwest, .94; South, .96; and West, .96.

From the foregoing studies it would appear that the inventory prepared by Dr. Byrd has substantial validity and reliability and was so judged by the author.

INTERESTS BY THE 21 MAJOR HEALTH AREAS

An analysis of the responses of 10,000 secondary school students to the health interest inventory revealed significant interests in the 21 major health areas as well as in specific health problems.

There were 6 to 25 items in each major health area. Table 1 indicates the rank order by interest of each major health area, the number of items in each area, the total number of responses to all the items in each area, and the percentage of interest in each area. The total number of responses to all items in the area was first divided by the number of items in the area, and second, by the total number of cases (10,000). The result indicated the percentage participation in each area by the entire group.

The major health area which received the greatest interest indication was Habit Forming Substances with a 39 per cent response. Many authorities have recognized the importance of including portions of this area in the secondary school curriculum. In fact, several states have made this mandatory by law. An example is the emphasis placed on the effects of tobacco and alcohol.

Marijuana is now receiving a great deal of attention, since it is so important a factor in juvenile delinquency.

The second area of greatest interest was Safety with a 38.7 percentage participation. Many states now have taken active steps to include courses in safety in the secondary curriculum. A conference on safety called by President Truman has brought national attention to this area.

The third area of greatest interest was Family Health with a 36.5 per cent indicated interest. Some of the items included in this area have been highly controversial. Regardless of this, more and more schools are including family health in their curriculums. These courses may include such specific items as sex education and menstruation. Some school systems, notably the Oregon Schools, have considered the area so important that they have produced their own films.

The next area of greatest interest was Mental Health with a 31.4 per cent of indicated interest. National emphasis was placed on this area in 1946 by the National Mental Health Act. Also, recent studies show that approximately one-sixth of the population is mentally ill or may become mentally ill.

The sixth area of greatest interest was Health as a Social Problem with a 31 per cent participation. This area has seldom been considered as an area of interest in a health course. This area, as well as other areas of considerable interest to the students which may also have national implications and significance, cannot be overlooked when constructing health courses.

The areas of least interest were Trends and Possibilities and International Health. These areas should be considered in the scope of the instructional program but, because they are of least concern to the students, need not be given the same emphasis as the areas of greatest interest.

The area of Nutrition has been given wide consideration by a large number of authors as a leading area of interest and importance to the students. This study demonstrated that Nutrition was only of "average" interest to students.

The differences of interest in the various areas were significant. Although there may be little or no significant difference in interest between two areas whose percentage of interest participation varies by only 1 per cent, there is significant difference of interest in areas varying by 10 per cent. Greatly significant, then, is the fact that there is as much as a variance of 20 per cent between areas, and that there is approximately twice as much interest in each of the five areas of greatest interest as there is in each of the five areas of least interest.

Also included in this study was a consideration of health interests of students according to geographical location. Table 2 indicates the comparative interest in major health areas by 10,000 secondary school students according to geographical location.

Although the sampling was limited as to the number of cases and schools from each geographical location, the study revealed the following factors. Students from each of four geographical areas of the United States indicated a high degree of interest in the various health areas. Each section of the United States had a very similar core of health interests. Seldom did the interest in a

TABLE 2

Interests in Major Health Areas by 10,000 Secondary School Students According to Geographical Location

Major Area	Cases				
	Total 10000	East 1900	Midwest 3510	South 1590	West 3000
	(Percentage of interest)				
Habit Forming Substances	39.4	39	42	36	38
Safety	38.7	41	40	38	36
Family Health	36.5	34	40	32	36
Mental Health	31.4	32	34	30	31
Exercise and Body Mechanics	31.2	32	33	30	30
Health as a Social Problem	31.0	32	34	28	28
Care of Special Organs	30.5	33	31	29	29
Health and the Physical Environment	28.1	30	28	27	28
Health as a Social Accomplishment	26.6	29	27	26	26
Chronic and Degenerative Disorders	26.5	26	29	25	25
Fatigue and Rest	26.4	28	27	26	24
Nutrition and Health	24.5	25	25	23	24
Infection and Immunity	24.4	25	26	23	24
School Health	23.3	23	28	22	23
Heredity and Eugenics	22.0	19	24	25	20
Community Health	21.6	24	22	21	21
Excretion and Health	19.1	19	19	18	19
Health Services and Facilities	18.9	20	19	17	19
Occupational Health	17.9	19	19	16	17
Trends and Possibilities	17.3	15	18	18	15
International Health	15.0	18	15	15	14

major health area in one location deviate from the mean interest for that health area for the entire group by more than 2 or 3 per cent. Considering that the number of cases representing each area was different, this deviation might normally be expected.

The average range of interest between the area of greatest interest and the area of least interest for the entire United States was 24 per cent and no one geographical section varied from this by more than 3 per cent. This indicates a high consistency of interest. From inspection of this data it is reasonable to conclude that there is a negligible difference in interest in the major health areas when considering the geographical locations of the United States.

A further comparison of the major health areas of the geographical locations of the United States with the entire study was made. The Pearson Product Moment of Correlation was used to determine the degree of agreement of pupil interests: (1) A comparison of the East with the entire study resulted in a correlation of .87. (2) The Midwest correlated .94 with the entire study. (3) The correlation of the South to the entire study was .96. (4) The relationship of the West to the entire study was .96.

There was a mean relationship of .93 between geographical regions of the United States and the entire study. From the high correlations obtained, it may be concluded that geographical differences have little or relatively no effect on the amount of interest in the major health areas.

SPECIFIC HEALTH INTERESTS OF 10,000 SECONDARY SCHOOL STUDENTS

A detailed analysis of the interest position of the entire 300 health problems used in this study may be found in Table 3. This table indicates the percentage of response to each item by the 10,000 cases as well as the percentage of interest by the cases of each geographical location. There was considerable variance as to the degree of interest which ranges from the leading item, Sex Instruction, with a 67 per cent response to the item of least interest, Function of the Health Coordinator, with a 7 per cent response.

The second greatest item of interest was Cancer with a 60 per cent response. High school pupils are very much interested in the disease that does not affect childhood, but rather is associated with the older age grouping.

The third item of greatest interest was Juvenile Delinquency, which is an immediate problem of this particular age group. The next item, Causes of Suicide, although not a specific problem of this age group, is sensational, and many references to it appear in newspaper headlines.

Tobacco and Human Health, the fifth item of greatest interest, has been a controversial issue in many homes. There have been many conflicting statements and many bits of evidence against smoking. Parents have been prone to condemn smoking by their children, yet parents themselves are frequent users of tobacco.

The sixth item of greatest interest, Problems of Tooth Decay, is a very real problem to school-age children. The tremendous number of dental caries among school children and the present emphasis on dental examinations and care has amplified the importance of this problem.

Interest in the seventh leading item, Causes of Mental Illness, is more difficult to explain, except that it may be sensational and has an aura of mystery.

Lifelong Care of the Eyes was the next greatest item of interest and according to age groupings is a very appropriate item. Most students receive some information in school about conservation of vision. Also, there has been a great national emphasis on the proper protection of eyesight.

The ninth item, Safest Age To Have a Baby, was of special interest to the girls; however, boys have been interested also.

The tenth item of interest, How To Use a Gun Properly, is especially pertinent to boys, and it logically can be assumed that the discussions concerning the war and the utilization of weapons has made this interest most prevalent.

In contrast to the above, the items of least interest, Function of the Health Coordinator and Rehabilitation on the Job received only 7 and 8 per cent responses, respectively. It is obvious that these items have had little direct relationship to the students.

Interest in specific items remained surprisingly consistent in all the geographical locations. Items of greatest interest in one geographical location were generally consistent among the items of greatest interest in the other geographical locations. Items of least interest followed the same pattern. However, there were several inconsistencies, all of which are relative to either the East or the West.

TABLE 3

An Item Analysis of Health Interests in Order of Preference of 10,000 Secondary School Students and a Comparison of Interests by Geographical Location

Order Per 10000	Health Problem	Cases				
		Total 10000	East 1900	Mid-West 3510	South 1590	West 3000
		(*Percentage of Interest*)				
1	Sex Instruction	67	61	73	66	65
2	Cancer	60	63	63	60	54
3	Juvenile Delinquency	60	55	67	43	66
4	Causes of Suicide	60	57	62	60	56
5	Tobacco and Human Health	57	57	61	55	53
6	Problems of Tooth Decay	54	61	58	50	50
7	Causes of Mental Illness	54	50	62	49	50
8	Lifelong Care of the Eyes	53	55	56	50	50
9	Safest Age To Have a Baby	53	52	58	45	50
10	How To Use a Gun Properly	52	57	53	57	44
11	How To Report Accidents	52	55	56	44	50
12	Speed and Accidents	52	51	55	57	46
13	Preparation for Marriage	51	43	57	49	52
14	Hit and Run Drivers	50	48	52	47	50
15	Safety in Water	50	63	57	53	32
16	Communicable Diseases	50	59	56	51	37
17	Sunburn	49	48	49	49	50
18	Drunken Driving	49	47	55	48	45
19	Cancer Is Inherited?	49	51	52	51	42
20	Jealousy	48	52	59	54	31
21	Problems of Alcohol	48	42	54	44	48
22	How To Have Good Posture	48	48	49	42	50
23	Danger of Sleeping Pills	47	51	47	43	47
24	Atomic Warfare	47	45	48	47	46
25	War and Disease	46	45	48	44	45
26	Child Labor	45	48	48	39	42
27	Effects of Tea and Coffee	45	50	45	42	44
28	Sports vs. Apparatus Activity	45	51	45	43	41
29	Deaths of Mothers in Childbirth	44	44	54	38	37
30	Pregnancy and Health	44	37	51	38	43
31	Schools and Juvenile Delinquency	44	37	48	37	47
32	Danger of the High I.Q.	43	37	46	44	42
33	Sweets and Dental Decay	43	50	41	33	45
34	Ways of Getting to Sleep	43	50	46	43	34
35	Conquest of Disease	43	41	42	39	46
36	Relaxation (Resting)	42	40	45	46	37
37	Common Sicknesses	41	45	40	39	41
38	The Ability to Have Children	41	31	49	38	39
39	Mental Health and Marriage	40	33	45	35	42
40	Births in Hospitals or at Home	40	37	45	32	40
41	Is there an "Athletic Heart?"	39	46	40	41	30
42	Can Drug Addicts be Cured?	39	37	44	28	37
43	Breast or Bottle Feeding	38	37	40	33	39
44	"Athlete's Foot"	38	46	38	36	36
45	The School Lunch	38	41	38	41	33
46	Home Accidents	38	43	40	33	33
47	Candy and Dental Health	37	40	35	38	37
48	Causes of Speech Disorders	37	40	44	36	30
49	Causes of Infant Deaths	37	37	40	29	38
50	Uses and Abuses of Narcotics	37	32	44	31	34
51	Health Hazards with Foods	37	39	38	38	34
52	Tuberculosis	37	40	38	31	37
53	Food During Pregnancy	36	28	41	33	36
54	Earthquakes	36	41	32	30	41
55	Best Number of Working Hours	36	36	35	41	33
56	Problems of Physical Unfitness	36	32	38	38	33
57	Atomic Radiation	36	40	45	44	18
58	Poliomyelitis (infantile paralysis)	36	34	40	29	33
59	Traffic Accidents and Laws	35	35	38	35	33
60	Psychological Basis of Crime	35	30	39	31	37
61	Social Diseases in Schools	35	27	38	35	37
62	Heart Disease and Public Health	35	36	36	34	33
63	Wax in Ears	35	41	32	35	34
64	Housing and Health	35	34	39	28	33
65	Military Drill vs. Physical Education	35	36	33	38	33
66	Value of X-Ray	35	42	39	38	22
67	Protecting Pedestrians	34	31	34	32	38
68	Artificial Respiration	34	36	35	31	33
69	Restaurant Sanitation	34	30	38	30	35

TABLE 3—*Continued*

Order Per 10000	Health Problem	Cases: Total 10000	East 1900	Mid-West 3510	South 1590	West 3000
		(*Percentage of Interest*)				
70	Poison Oak	34	39	27	26	43
71	Marihuana	34	28	41	38	30
72	Parking and Traffic Accidents	34	30	32	37	37
73	Mosquito Control	34	33	34	40	30
74	Bicycle Safety	34	50	31	28	29
75	Reasons for Poor Hearing	33	35	35	33	29
76	Major Health Problems	33	36	35	31	31
77	Fires	33	43	32	28	29
78	Paralysis from Crossing Legs	33	34	33	28	35
79	Traffic Accidents, National Problem	33	34	34	36	28
80	Tuberculosis and Pregnancy	33	27	34	24	39
81	Rats and Health	33	33	37	32	28
82	Aviation Safety	33	30	34	33	32
83	Closing Schools During Epidemics	33	35	35	27	30
84	Menstrual Problems	32	26	37	28	34
85	Cancer of the Bowel	32	35	34	27	31
86	Nutrition and Overweight	32	32	34	25	33
87	Early Rising after Childbirth	32	28	34	28	32
88	Infant and Maternal Deaths	32	32	35	25	31
89	Laxatives and Appendicitis	32	34	31	28	33
90	Social Diseases	32	20	40	35	27
91	Hayfever	32	32	34	27	31
92	Sunlight and Health	32	31	32	31	32
93	Life Expectancy in U.S.	31	31	30	32	33
94	Penicillin and Infection	31	30	32	29	32
95	Water Contamination	31	29	34	31	29
96	Mental Hygiene of the Normal Person	31	38	29	25	33
97	Exercise and Menstruation	31	23	37	28	31
98	Handshaking and Disease	31	27	34	31	31
99	Radium and X-Ray	31	32	31	32	30
100	Occupational Skin Diseases	31	25	34	27	33
101	Treasury Department and Narcotics	31	31	34	27	29
102	Cooking and Food Values	31	32	32	28	31
103	Milk Pasteurization	31	41	27	28	31
104	Epilepsy and Pregnancy	31	27	34	26	32
105	The Cross-eyed Child	31	35	33	24	30
106	Floods	31	35	31	26	29
107	Prevention of Mental Illness	30	27	34	28	28
108	Road Conditions and Accidents	30	27	31	28	32
109	Preventing Infections	30	27	34	27	29
110	Rheumatic Fever	30	32	31	25	30
111	Causes of Ingrown Toenails	30	34	30	32	25
112	Nervous Fatigue	29	27	33	28	28
113	Age and Capacity to Exercise	29	33	29	28	28
114	Blasts and Explosions	29	32	26	33	30
115	Local Health Units	29	31	30	32	26
116	Types of Mental Disorders	29	25	34	25	28
117	Railroad Safety	29	27	29	19	35
118	Hospital Services	29	27	30	28	29
119	Mental Hygiene in Babyhood	29	27	33	22	29
120	Safety in the Home	29	30	29	25	30
121	Pneumonia	29	31	27	26	30
122	Exercise and Food Needs	29	29	29	28	28
123	Vaccinations for Children	28	30	28	24	30
124	Eye Examinations	28	28	28	27	29
125	Flat Feet	28	34	24	30	28
126	Facts about Milk	28	36	21	27	32
127	Sewage Disposal	28	27	30	26	26
128	Hospital Insurance	28	29	30	28	24
129	Effects of Life in Tropics	28	32	27	26	27
130	Posture and Tuberculosis	28	24	30	22	29
131	Ear Infections in Childhood	27	30	27	24	27
132	Use of Germs in Warfare	27	27	29	28	24
133	Vision Testing in Schools	27	25	27	27	28
134	Are Nose Drops Harmful?	27	31	25	25	27
135	Heat Stroke	27	27	29	22	26
136	Home Care of the Sick	27	29	27	19	27
137	Fatigue and Broken Bones	26	27	26	27	26
138	Hospitals of the Future	26	27	28	21	26
139	Infant and Child Feeding	26	27	28	19	26
140	The R.H. Blood Factor	26	27	30	21	22

TABLE 3—*Continued*

Order Per 10000	Health Problem	Cases Total 10000	East 1900	Mid-West 3510	South 1590	West 3000
		(*Percentage of Interest*)				
141	Milk and Dairy Sanitation	26	20	27	26	22
142	Diphtheria	26	32	24	22	25
143	Health Resorts	26	27	27	26	23
144	High Winds and Tornadoes	26	26	24	28	25
145	Severe Muscle Weakness	25	31	24	26	22
146	Is Rheumatic Fever Inherited?	25	26	31	25	18
147	Socialized Medicine	25	25	32	25	18
148	Frostbite	25	30	28	22	20
149	School Medical Service	25	24	26	26	22
150	Mental Disorders in Armed Forces	25	24	26	24	25
151	Rest for Children	25	33	25	17	22
152	Fatigue as a Health Problem	25	22	29	26	21
153	Dust and Disease	25	26	26	22	22
154	Storing, Freezing and Canning Foods	24	26	22	22	27
155	Health Problem of the Negro	24	27	29	22	18
156	Rat Control Program	24	28	23	19	24
157	The Nursing Profession	24	24	24	19	26
158	Old-Age—Special Problems	24	24	25	24	22
159	Effects of High Pressure	24	21	22	30	23
160	Whooping Cough	24	26	19	18	30
161	Tuberculosis Testing in Schools	24	21	24	20	27
162	Convulsions in Children	24	22	26	17	26
163	Hearing Testing in Schools	23	22	24	21	23
164	Cancer Preventive Clinics	23	23	22	23	24
165	Work of School Nurse	23	26	24	21	21
166	Food Deficiencies	23	21	22	24	24
167	Fatigue Caused by Disease	23	21	28	22	19
168	Practical Selection of Foods	23	19	27	25	20
169	School Health Programs	23	22	23	22	23
170	Medical Emergencies of the Eye	23	23	22	20	25
171	Ring Worm of the Scalp	23	22	24	19	23
172	Volcanoes	23	26	21	14	27
173	Trench Foot	22	24	21	22	22
174	The Vitamin Problem	22	26	21	26	19
175	Vaccination for Tuberculosis	22	23	21	19	24
176	Disease and International Travel	22	21	27	22	16
177	Is Epilepsy Inherited?	22	16	26	24	21
178	Animals in Medical Research	22	26	21	19	21
179	Tonsil and Adenoid Operations	22	22	24	20	20
180	Battle Fatigue	22	21	21	24	21
181	Motion Sickness	22	22	24	21	19
182	Leading Communicable Diseases	22	23	21	20	21
183	DDT and Disease Control	22	24	18	24	22
184	Chlorination of Water	21	22	22	17	22
185	Smallpox	21	22	20	22	23
186	Health Effects of Radar	21	21	22	19	21
187	Family Health Insurance	21	18	22	22	21
188	Insects and Disease	21	22	22	17	21
189	Kidney and Urinary Diseases	21	20	24	18	21
190	Medicine as a Profession	21	21	21	22	31
191	Head Lice in School Children	21	26	23	18	17
192	World Food and Medical Relief	21	23	18	22	23
193	Accident Dangers in Industry	21	23	20	18	22
194	International Death Rate	21	20	29	16	14
195	United States Public Health Service	21	22	19	18	22
196	Eye Bank for Eye Restoration	21	19	20	16	24
197	Blood Donor Service	21	24	20	18	20
198	High Altitudes	21	19	20	22	21
199	Varicose Veins	21	17	24	16	22
200	Exposure to Colds	21	22	21	19	20
201	Causes of Absence from Work	20	21	22	18	19
202	Farm Accidents	20	24	19	20	20
203	Health Accomplishments of States	20	24	19	18	20
204	Health of Women in Industries	20	21	20	17	21
205	State Vaccination Laws	20	20	21	18	20
206	Aids to Hearing	20	23	19	22	19
207	Desirable Vaccinations for Everyone	20	17	21	18	20
208	Diseases of Intestines	20	17	22	18	20
209	Mental Health in Industry	20	21	24	22	12

TABLE 3—*Continued*

Order Per 10000	Health Problem	Cases: Total 10000	East 1900	Mid-West 3510	South 1590	West 3000
		(Percentage of Interest)				
210	Health and Income	20	15	22	22	19
211	Rest and Tuberculosis	20	22	19	14	21
212	National Science Foundation	20	19	21	19	18
213	Infections of the Liver	20	21	19	19	20
214	Importance of Minerals	20	26	17	20	18
215	Worm Infections as a World Health Problem	19	21	19	17	20
216	Constipation	19	17	19	19	20
217	Why Have Flourine in the Water?	19	20	20	17	19
218	Contact Lenses	19	11	24	14	21
219	Dietician	19	15	15	13	29
220	Influenza	19	20	19	17	20
221	Kidney and Urinary Stones	19	20	24	18	13
222	Disease and Heredity	19	13	22	18	20
223	Arthritis and Rheumatism	19	18	21	17	17
224	National Food and Drug Act	19	17	21	17	17
225	Community Milk Regulation	19	26	17	19	14
226	Heredity and High Blood Pressure	18	14	19	18	20
227	Life Expectancy in Other Countries	18	20	19	16	17
228	Health Problems of Management	18	26	20	14	13
229	Chronic Ulcers	18	18	19	17	17
230	Diabetes	18	13	18	22	20
231	Vaccination Against Measles	18	21	18	14	19
232	Job Opportunities in Public Health	18	20	19	12	18
233	White Bread and Epilepsy	18	12	24	13	17
234	Ragweed Control	18	11	15	12	28
235	World Wide Epidemics	18	19	18	15	18
236	Public Health Clinics	18	17	19	14	18
237	Allergy and Heredity	18	13	21	16	17
238	Vaccinations against "Flu"	17	17	16	20	17
239	Pharmacy	17	19	17	16	17
240	Noise and Vibration	17	18	16	17	17
241	The Ulcer Problem	17	15	17	14	19
242	The Health Course	17	16	18	13	17
243	National Mental Health Act	17	11	9	9	33
244	The Dental Profession	17	20	15	16	16
245	Poisoning and Bromides	17	18	15	13	19
246	Diabetes and Heredity	17	13	18	16	17
247	Poor Soil and Health	17	18	16	18	15
248	International Food Crisis	16	18	15	17	16
249	Radiant Disinfectant in School Rooms	16	16	15	14	17
250	Psychological Warfare	16	12	15	17	17
251	Vacations Prescribed by Doctors	16	18	13	14	20
252	Physically Handicapped in Industry	16	16	17	13	15
253	Rehabilitation of the Handicapped	16	13	19	13	15
254	Shipping Related to Disease	16	17	16	15	13
255	American Medical Platform	16	14	15	17	15
256	Facts in Human Nutrition	15	14	18	11	15
257	Prevalence of Emotional Disturbances	15	9	16	16	17
258	Death Rate Trends	15	19	14	16	14
259	Encephalitis (Brain Inflamation)	15	14	15	13	16
260	Harmful Effects of Mineral Oil	15	18	14	17	13
261	Blood Testing	15	16	15	17	12
262	Foods and Industrial Workers	14	20	14	12	14
263	Health Dangers in Occupations	14	15	15	15	12
264	Physical Therapists	14	11	16	13	13
265	Diarrhea and its Significance	14	13	14	13	16
266	Health Problems of Migrant Population	14	13	17	9	13
267	Other Communicable Diseases	14	13	14	12	15
268	Food and Learning Ability	14	11	14	14	16
269	Exercise and Convalescence	14	14	14	14	13
270	Slowing Down Mental Decline	14	13	14	13	15
271	Thermometers	13	16	13	12	14
272	The Preschool Roundup	13	13	14	13	12
273	Fatigue in Industry	13	12	14	12	12
274	World Food Conference	13	11	15	10	12
275	Health for Grandparents	12	17	14	13	6
276	National Health Contests	12	13	9	8	17
277	Septic Tanks	12	12	13	16	11
278	World Health Organization	12	11	9	10	17

TABLE 3—*Continued*

Order Per 10000	Health Problem	Cases: Total 10000	East 1900	Mid-West 3510	South 1590	West 3000
		(*Percentage of Interest*)				
279	Leading World Health Problems	12	11	13	13	12
280	Making Vitamins in the Intestines	12	11	9	13	13
281	Labor Management Health Contracts	12	11	14	9	10
282	Health Inspection by Teachers	12	14	9	10	13
283	Industrial Dusts and Health	12	13	13	10	11
284	Medical Eugenics	12	9	14	10	11
285	Taft-Smith National Health Bill	12	12	13	11	11
286	Significance of Urinalysis	11	9	14	9	11
287	Cabinet Post of Health	11	13	9	12	10
288	Inter-American Health	11	11	10	10	11
289	Activities of Local Health Officers	10	12	9	10	10
290	Health Aspects of Proteins	10	9	14	10	8
291	Practical Eugenics	10	7	10	9	10
292	Intolerance to Exercise	9	7	9	9	10
293	Values of Industrial Health Programs	9	10	8	9	10
294	Wagner-Murray-Dingell Health Bill	9	12	8	10	8
295	Choosing a Health Advisor	9	11	6	9	10
296	Reliability of Health Information	9	8	9	8	9
297	Hospital Construction Act	9	8	6	9	10
298	Problems of Industrial Solvents	8	6	6	6	15
299	Rehabilitation on the Job	8	7	8	8	8
300	Function of the Health Coordinator	7	7	6	8	6

In the eastern group Fires, Bicycle Safety, Safety in the Water, Milk Pasteurization, and Facts about Milk had a significantly higher interest response than did these same items in the other geographical locations. Other items in the areas of Nutrition and Safety did not show a correspondingly high interest response. Social Diseases and Social Diseases in School both showed an extremely low interest rating in the eastern group.

The students of the western group demonstrated comparatively high interests in Dieticians, National Mental Health Act, Ragweed Control and Poison Oak. The National Mental Health Act was passed in 1946 and received considerable publicity. Since the western group was inventoried soon after the passing of this act, the time element may account for the high interest. The item Poison Oak may be of high interest to students of California because of extensive outdoor activities on the part of pupils in this state.

In the West, Atomic Radiation, Jealousy, and Communicable Diseases showed a low interest rating. The fact that all three sections of the country had a higher interest rating in Atomic Radiation than did the West may be due to the timing of the study. While the western Study was conducted in 1947–48, the study over the other sections of the United States was conducted during 1950 at which time there was great emphasis on defense against the atomic bomb.

HEALTH INTERESTS AS DETERMINED BY SEX

The 50 items of greatest interest to boys will be found in Table 4, and the 50 items of greatest interest to girls in Table 5. Eighty-nine per cent of these items were identical. Table 6 records the items which appear in the 50 items of greatest interest to boys and do not appear in the 50 items of greatest

TABLE 4

The 50 Leading Health Interests of 5,215 Secondary School Boys

Order	Health Problem	Per Cent Interested
1	Sex Instruction	65
2	Safety in Water	64
3	Tobacco and Human Health	61
4	How To Use a Gun Properly	60
5	Sports vs. Apparatus Activity	58
6	Atomic Warfare	58
7	Juvenile Delinquency	58
8	Speed and Accidents	56
9	Cancer	56
10	Causes of Suicide	55
11	Problems of Tooth Decay	54
12	How to Report Accidents	51
13	Hit and Run Drivers	51
14	Drunken Driving	50
15	Lifelong Care of the Eyes	50
16	Problems of Alcohol	48
17	War and Disease	47
18	Causes of Mental Illness	45
19	Danger of the High I.Q.	43
20	Cancer Is Inherited?	43
21	Atomic Radiation	43
22	Is There an "Athletic Heart?"	43
23	Effects of Tea and Coffee	42
24	Safest Age To Have a Baby	42
25	Child Labor	42
26	"Athlete's Foot"	42
27	Danger of Sleeping Pills	42
28	Sweets and Dental Decay	41
29	Ways of Getting to Sleep	41
30	Conquest of Disease	41
31	Traffic Accidents and Laws	40
32	Sunburn	40
33	Communicable Diseases	40
34	Preparation for Marriage	40
35	How To Have Good Posture	40
36	Relaxation (resting)	39
37	Schools and Juvenile Delinquency	39
38	Traffic Accidents—National	39
39	Best Number of Working Hours	38
40	The Problem of Physical Unfitness	38
41	Uses and Abuses of Narcotics	38
42	Jealousy	38
43	Health Hazards with Foods	37
44	Can Drug Addicts be Cured?	37
45	The School Lunch	37
46	Mosquito Control	37
47	Treasury Department and Narcotics	37
48	Earthquakes	36
49	Common Sickness	36
50	Bicycle Safety	36

interest to girls, and Table 7 records the items which appear in the 50 items of greatest interest for girls and not for boys.

TABLE 5

The 50 Leading Health Interests of 4,785 Secondary School Girls

Order	Health Problem	Per Cent Interested
1	Sex Instruction	70
2	Juvenile Delinquency	67
3	Cancer	64
4	Causes of Suicides	64
5	Preparation for Marriage	64
6	Safest Age To Have a Baby	64
7	Causes of Mental Illness	64
8	Jealousy	60
9	Sunburn	58
10	Pregnancy and Health	58
11	Deaths of Mothers in Childbirth	57
12	Problems of Tooth Decay	57
13	Lifelong Care of the Eyes	56
14	Communicable Diseases	55
15	The Ability to Have Children	54
16	Cancer is Inherited?	54
17	Tobacco and Human Health	54
18	How To Report Accidents	51
19	Dangers of Sleeping Pills	51
20	Births in Hospitals or at Homes	51
21	Safety in Water	50
22	How to Have Good Posture	50
23	Mental Health and Marriage	50
24	Schools and Juvenile Delinquency	49
25	Problems of Alcohol	49
26	Hit and Run Drivers	49
27	Food During Pregnancy	49
28	Child Labor	49
29	Common Sickness	48
30	Menstrual Problems	48
31	Effects of Tea and Coffee	48
32	Breast or Bottle Feeding	48
33	Causes of Infant Deaths	47
34	Drunken Driving	47
35	Sweets and Dental Decay	47
36	Exercise and Menstruation	47
37	Speed and Accidents	46
38	Ways of Getting to Sleep	45
39	Infant and Maternal Deaths	45
40	Military Drills versus Physical Education	45
41	War and Disease	44
42	Early Rising After Childbirth	43
43	Nutrition and Overweight	43
44	Poliomyelitis (infantile paralysis)	43
45	Housing and Health	43
46	How To Use a Gun Properly	43
47	Dangers of the High I.Q.	42
48	Home Accidents	42
49	Tuberculosis and Pregnancy	41
50	Causes of Speech Disorders	41

It may be seen from these tables that the patterns of masculine and feminine interest follow along the lines of the generally accepted roles the male and female should assume in society. The girls were interested more than the boys

TABLE 6

Items Included in the 100 Items of Greatest Interest to Boys Which Are Not Included in the 100 Items of Greatest Interest to Girls

Health Problem	Percentage of Interest
Atomic Radiation	43
Is There an "Athletic Heart?"	43
Relaxation (resting)	39
Traffic Accidents—National Problem	39
Treasury Department and Narcotics	37
Aviation Safety	34
Road Conditions and Accidents	34
Water Contamination	33
Age and Capacity for Exercise	32
Floods	32
Local Health Units	30

TABLE 7

Items Included in the 100 Items of Greatest Interest to Girls which are not Included in the 100 Items of Greatest Interest to Boys

Health Problem	Percentage of Interest
Menstrual Problems	48
Exercise and Menstruation	47
Infant and Maternal Deaths	45
Ways of Getting To Sleep	45
Early Rising after Childbirth	43
Nutrition and Overweight	43
Cooking and Food Values	40
Mental Hygiene in Babyhood	40
Paralysis from Crossing Legs	38
Mental Hygiene of Normal Persons	36
Laxatives and Appendicitis	36

in items that personally concern them; such as, menstruation, childbearing and nutrition. The boys were more interested than the girls in the areas of physical activity and safety.

A further breakdown was made of the health interests of boys and girls according to the grade in school. This analysis was conducted only on the 3,000 cases of the West. See Table 8 for further analysis of health interests according to sex and grade in school.

Conclusions

1. Health interests of high school students can be measured with a high degree of reliability.

2. There is a very high level of pupil interest in health problems. The 10,000 students participating in this study indicated interests which averaged 75 health problems per student.

3. There is a wide range of pupil interest in specific health items varying from 67 per cent interested in Sex Instruction to 7 per cent interested in Function of the Health Coordinator.

4. There is a common core of health interests among high school students regardless of age or sex which should prove useful for curriculum construction.

TABLE 8

Items of Greatest Interest to 3,000 Secondary School Students of the West According to Grade and Sex

Class and Sex	Health Problem	Percentage of Interest
FRESHMEN AND SOPHOMORE BOYS		
	Juvenile Delinquency	60
	Atomic Warfare	57
	Sex Instruction	57
	Tobacco and Human Health	53
	Hit and Run Drivers	52
	How to Report Accidents	51
	How to Use a Gun Properly	51
	Sports vs. Apparatus Activity	51
	Causes of Suicide	51
	Cancer	49
JUNIOR AND SENIOR BOYS		
	Sex Instruction	63
	Sweets and Dental Decay	60
	Juvenile Delinquency	60
	Tobacco and Human Health	59
	Atomic Warfare	57
	Causes of Suicide	55
	How to Report Accidents	52
	Speed and Accidents	52
	Cancer	52
	Hit and Run Drivers	51
FRESHMAN AND SOPHOMORE GIRLS		
	Juvenile Delinquency	69
	Sex Instruction	63
	Safest Age to Have a Baby	60
	How to Have Good Posture	57
	Causes of Suicide	57
	Preparation for Marriage	57
	Cancer	56
	Lifelong Care of the Eyes	55
	Causes of Mental Illness	53
	Dangers of Sleeping Pills	52
JUNIOR AND SENIOR GIRLS		
	Sex Instruction	77
	Preparation for Marriage	73
	Juvenile Delinquency	73
	Causes of Mental Illness	66
	Causes of Suicide	66
	Safest Age to Have a Baby	65
	Cancer	62
	Pregnancy and Health	62
	Lifelong Care of the Eyes	59
	Mental Health and Marriage	58

5. Geographical location seems to have little or no infleunce on health interests as expressed by students. Of the 300 items only a few items showed significant variation.

6. The largest variation in health interests occurred between the sexes, even though approximately 90 per cent of the health items of greatest interest to boys and the health items of greatest interest to girls are identical. The variations should prove useful for segregated classes. Girls are more interested than

boys in problems that personally concern them; such as, menstruation, child-bearing, and nutrition. Boys are more interested than girls in problems relative to physical activity and safety.

7. There are some variations in health interests by grade placement, but such differences in interest were few in number.

8. Many health problems long considered by teachers to have little interest appeal to pupils have been shown to rank extremely high in student interest. Cancer and Problems of Tooth Decay, ranking second and sixth in student interest, are good examples of this.

9. High interest in a major health area does not imply that all problems within that area were of high interest to students, and similarly, low interest in a major health area does not imply that all problems within that area were of low interest to students. Rather, there may be specific items of both low and high interest in each major health area.

10. It should be possible to improve the quality of learning experiences in health in the school curriculum by the utilization of the health interests discovered in this study.

Recommendations

1. All curriculum directors and teachers of health on the secondary school level should explore pupil health interests as a basis for partial determination of curriculum content.

2. Individual instructors should be encouraged to survey their classes to determine health interests.

3. The health instructors should alter the content of their courses to conform to the interests of the students in their classes.

4. Health classes should not necessarily be segregated by sex, inasmuch as there is a fairly common community of health interests among boys and girls.

5. On the basis of pupil interests the secondary school curriculum should place more emphasis on the major health areas of greatest student interest; particularly, Habit Forming Substances, Safety, Family Health, Mental Health, Exercise and Body Mechanics, and Health as a Social Problem.

6. The wide variety of health interests shown by high school pupils calls for highly qualified health educators who have a breadth of preparation now seldom seen in actual practice.

7. Student interests and needs are not always synonomous, but often correlate to a surprising extent. Instructors must exercise due caution to consider *both* interests and needs of students while constructing curricula and altering health courses.

Relationship of the War-Time Navy Physical Fitness Test to Age, Height, and Weight

JAMES C. LOVELESS

Grove City College
Grove City, Pennsylvania

THE PURPOSE of this study was to observe the relationship of the scores made on the Navy Standard Physical Fitness Test to age, height, and weight. Similar observations have been reported based on findings resulting from the Army Air Forces Physical Training Program.[1]

Description of the Test

The items included in the Navy Fitness Test were (1) Squat-thrusts, (2) Sit-ups, (3) Push-ups, (4) Squat-jumps, and (5) Pull-ups. "Standard" scores on these five items were averaged to give the complete test score.

According to the authorities who designed the test, the purpose was to test strength, stamina, endurance, and some degree of agility.

More specifically the five-fold test was given for the following purposes:

(a) To determine the physical fitness of the men when they arrive for training.

(b) To provide information that would help in adapting the physical fitness program to the men's needs.

(c) To motivate the men toward a higher level of physical fitness.

(d) To measure the progress of the men after being in service a specific length of time.

(e) To provide a means of measuring the physical fitness of Navy personnel of other activities.

(f) To determine whether or not the physical fitness program is accomplishing its desired results.[2]

Collecting the Data

The data for this study were collected at the Miami Naval Training Station, Miami, Florida, during the period March 1943 to March 1944. Athletic Specialists especially trained to give the Navy test acted as testers. Approximately 15,000 men were given the test and a chance selection of 5,669 cases was used for the study.

Men included in the study were (1) officers, whose ranks were Ensigns, Lieutenants (junior grade), Lieutenants, and Lieutenant Commanders, who were in training in the following departments: Communications, Gunnery, Operations, Navigation, and Steam and Diesel, (2) Rated enlisted men in training in the following schools: Quartermasters, Signal, Steam and Diesel, Stewards, Supply, and Yeoman, and (3) Non-rated enlisted men in training in the Seamenship Department and the Yeoman and Supply Schools.

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[1] Leonard A. Larson, Some Findings Resulting from the Army Air Forces Physical Training Program, *Research Quarterly*, **17:** 144–161, 1946.

[2] Bureau of Naval Personnel, Training Division, Physical Fitness Section, *Physical Fitness Manual for the U. S. Navy* NavPers 15,007, 1943, p. 17.

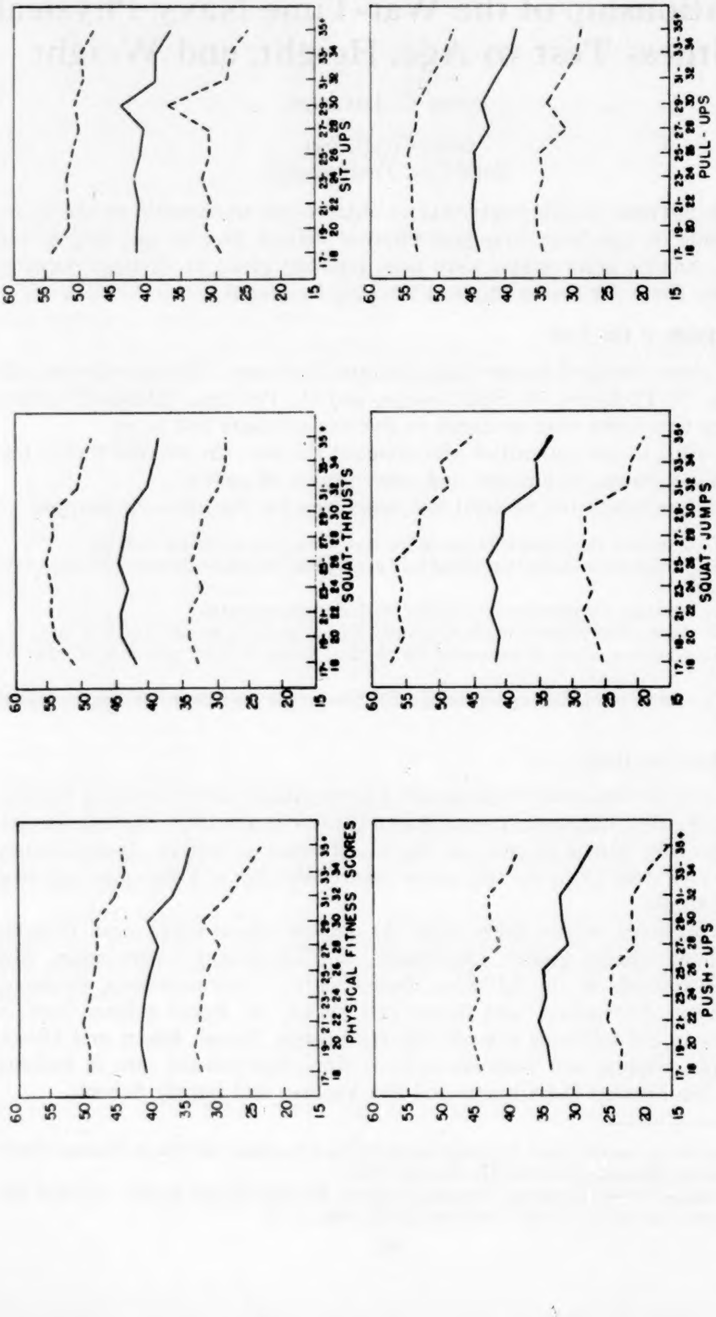

Fig. I. Fitness Test Scores and Item Scores Related to Age. (Vertical axis gives standard scores; horizontal axis gives age in years. Solid line shows the mean; broken lines show the standard deviation.

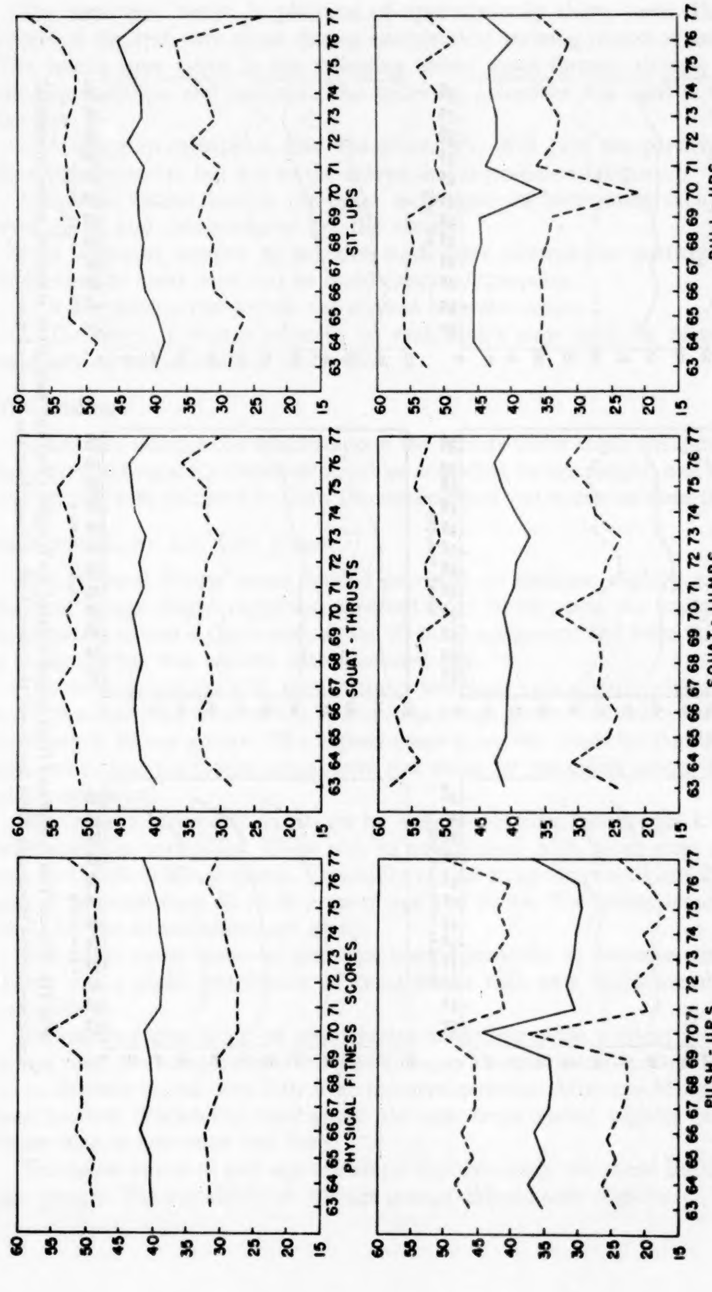

Fig. II. Fitness Test Scores and Item Scores Related to Height. (Vertical axis gives standard score; horizontal axis gives height in inches. Solid line shows the mean; broken lines show the standard deviation).

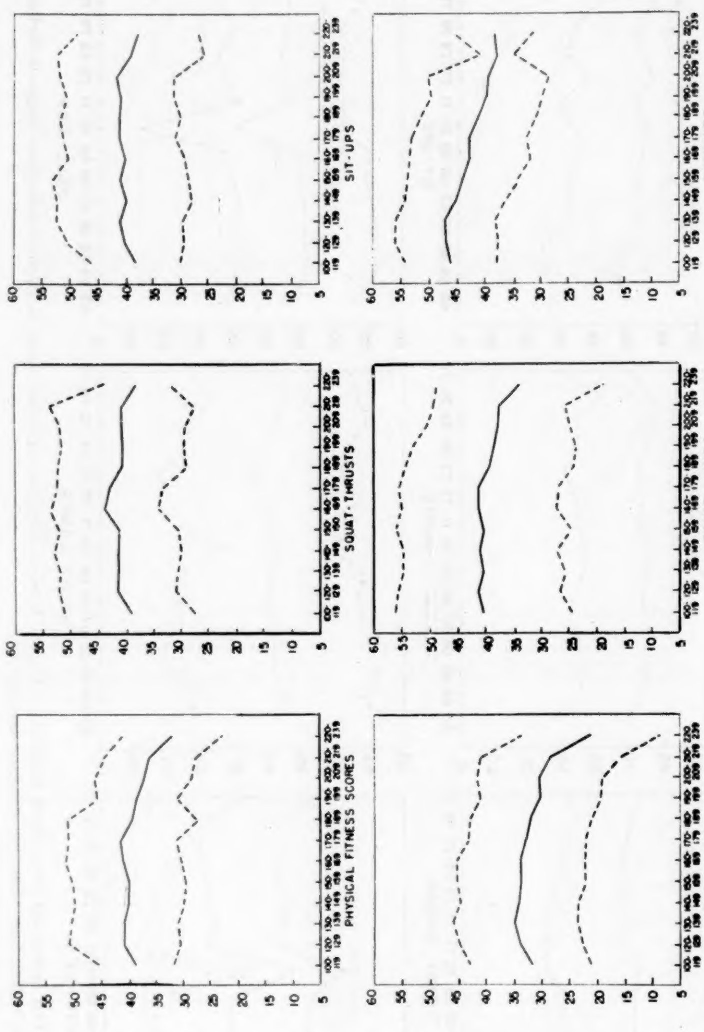

Fig. III. Fitness Test Scores and Item Scores Related to Weight. (Vertical axis gives standard score; horizontal axis gives weight in pounds. Solid line shows the mean; broken lines show the standard deviation).

The men were tested in platoons of approximately thirty men. The five events of the test were given during one physical training period of an hour. The events were taken in the following order: squat-thrusts, sit-ups, push-ups, squat-jumps, and pull-ups. The following procedure was used in taking the test:

1. A warm-up calisthenic drill was given. The drill gave the participant a thorough warm-up, but not to the extent that it produced fatigue.
2. Specific instructions in the exact techniques for performing each event were given and demonstrated by the tester.
3. A sufficient number of practice trials were allowed the participant in each event to make sure that he could execute it properly.
4. A five-minute rest period was allowed between events.
5. The tester in charge recorded on each man's score card the number of successful attempts made in each event.

The Findings

In order to observe the relationship of the factors under study the data were tabulated in frequency distribution tables according to age, height, and weight and graphs were prepared to show the regression of test scores on these factors.

TEST SCORES BY AGE (*See Figure I*)

The physical fitness scores tended generally to decrease slightly with an increase in age. Slight regression occurred from 19–28 years. An unexplained acceleration causes a slight peak at the 29 to 30 age group; and from this peak a sharp decline was noticed with increased age.

The mean scores made on squat-thrusts increased very slightly with ages 17 to 26. A minor peak was reached by the 25 to 26 age group. Variability remained constant in all age groups. The highest mean score was made by the 25 to 26 age group, and the lowest mean score was made by the oldest group, 35 and above age group.

The mean scores made on sit-ups by age were constant from ages 17 to 28 with constant variability. There was an unexplained high mean score on sit-ups by the 29 to 30 age group. Variability of this group was much less. Regression accelerated from 31 to 35 years of age and above. The lowest scores were made by the 35 and above age group.

The mean scores made on push-ups tended generally to decrease with age. There was a slight irregularity of mean scores with only slight variation in variability.

The mean scores made on squat-jumps tended to cause a wider spread of scores than the other items of the test for age. The mean scores made by ages 17 to 30 years varied very little from the average mean. After age 30 regression was marked. Variability throughout the age range varied slightly but was wider than in any other test item.

The mean scores of pull-ups remained approximately the same through all age groups. The variability of the age groups differed only slightly.

TABLE 1

Frequencies of Cases in Various Age, Height, and Weight Groups

Age (yr.)

	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31–32	33–34	35–up	Total
Cases	631	1045	1081	790	600	450	300	267	207	298	5669

Height (in.)

	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	Total
Cases	55	76	163	373	508	717	821	910	793	666	307	164	83	25	8	5669

Weight (lb.)

	100–119	120–129	130–139	140–149	150–159	160–169	170–179	180–189	190–199	200–209	210–219	220–239	Total
Cases	26	106	484	975	1275	1135	842	464	212	97	44	19	5669

TABLE 2

Comparison of Coefficient of Correlation, r, *and Standard Error, Indicating the 5% and 1% Levels of Confidence, of Variables among Age, Height, and Weight*
(Pearson Product Moment Method)

Variables		Coefficient of Correlations	Standard Error	Significance of S.E. of r	.05	.01
Physical Fitness Test	Age	−.26	.0123	Significant	Significant	Significant
	Height	.216	.0126	Significant	Significant	Significant
	Weight	−.07	.0132	Significant	Significant	Hardly Signif.
Squat-thrusts	Age	−.177	.0128	Significant	Significant	Significant
	Height	.06	.0132	Significant	Hardly signif.	Not signif.
	Weight	.00	.0132	Not signif.	Not signif.	Not signif.
Sit-ups	Age	−.097	.0131	Significant	Significant	Significant
	Height	.15	.0129	Significant	Significant	Significant
	Weight	.129	.0124	Significant	Significant	Significant
Push-ups	Age	−.11	.0131	Significant	Significant	Significant
	Height	.10	.0131	Significant	Significant	Significant
	Weight	.094	.0131	Significant	Significant	Barely signif.
Squat-jumps	Age	−.16	.0129	Significant	Significant	Significant
	Height	.063	.0132	Significant	Barely signif.	Not signif.
	Weight	.156	.0129	Significant	Significant	Significant
Pull-ups	Age	−.163	.0129	Significant	Significant	Significant
	Height	−.13	.0130	Significant	Significant	Significant
	Weight	−.213	.0126	Significant	Significant	Significant

TEST SCORES BY HEIGHT (*See Figure II*)

There was no noticeable change in physical fitness mean scores with an increase in height. Mean height scores were steady with the exception of the three

irregularities at 66 in., and 70 in., and 77 in. Variability was irregular, gradually increasing through intervals 63 in. to 70 in. Variability was greater at 70 in. and tended to be less at the 71 in. to 76 in. groups. Men 66 in. and 77 in. had the greatest mean fitness score.

Height did not affect appreciably the squat-thrust mean scores. These were slight variations at the 70 in., 75 in., and 76 in. groups. The lowest mean score was made at the 63 in. interval. Variability remained constant except at the 76 in. group where there was slightly less variability.

There was a steady progression in mean sit-up scores with an increase in height with the exception of slightly lower mean scores made by the 71 in. and 74 in. groups, these were minor irregularities and did not affect the picture perceptibly. There was varied variability. The least variability was at the 72 in. interval where the number of cases was large. Greatest variability occurred at the 77 in. interval, where the number of cases was small.

Push-up mean scores tended to decrease with an increase in height except at the 70 in. and 77 in. intervals. Smallest variability accompanied the highest mean score at the 70 in. interval. Other variabilities tended to remain steady except slightly greater at the 73 in. group.

There were very slight changes in squat-jump mean scores with increase in height. Slight irregularities in mean scores were noted between the 63 in. to 73 in. groups. Marked acceleration in progression was noted at the 74 in., 75 in., and 76 in. intervals dropping at the 77 in. group. There was considerable difference between the greatest and smallest variability. The greatest variability was at the 63 in. group and the smallest was at the 70 in. group.

Pull-up mean scores were steady forming two similar plateaus separated by an unexplained regressive dip at the 70 in. interval. The highest mean scores were made by the 64 in., 65 in., and 66 in. groups, and the lowest mean scores by the 70 in. group. Variability was irregular. The least variability was at the 77 in. interval. Greater variability occurs from 63 in. to 76 in. groups with the greatest at the 70 in. group.

TEST SCORES BY WEIGHT *(See Figure III)*

There was a general decrease in mean physical fitness scores with increase in weight. The mean fitness score regression was steady with the exception of two irregularities at 160 to 169 and 170 to 179 lb. intervals where there were slight increases in mean scores over the two preceding intervals. Variability was smallest at the 100 to 119 lb. interval. It increased slightly from the 120 to 129 to the 180 to 189 lb. group. Variability was greatest at the 180 to 189 lb. interval. Men in the 220 to 239 lb. group made the lowest mean physical fitness score.

Squat-thrusts scores tended to be lowest at the 100 to 119 and 220 to 239 lb. intervals, the two extreme groups. A plateau of nearly identical mean scores occurred between the 120 to 129 and 150 to 159 lb. intervals. A peak was formed by the high mean score at the 160 to 169 lb. group. After a slightly lower mean score at the 170 to 179 lb. group a second plateau was formed, slightly lower than the first, between 180 to 189 and 210 to 219 lb. intervals.

Variability was widest at groups 100 to 119 and 210 to 219 lb. and smallest at the 220 to 239 lb. interval. Variability was essentially the same at other parts of the profile.

Mean sit-up scores in relation to weight were more nearly the same regularly than in any other test item. The high mean score was made by the 200 to 219 lb. group and the low mean was made by the 220 to 239 lb. group. Means at other intervals were constant with little irregularity. Variability was smallest at the 100 to 119 lb. group, and there was wider variability at 140 to 149, 180 to 189, and 210 to 219 lb. groups.

In relation to weight the greatest range in mean scores was for push-ups. The push-up scores generally decreased with an increase in weight. There was slight progression in push-up scores from 100 to 119 to 130 to 139 lb. groups after which there was a gradual regression reaching the lowest mean score at the 220 to 239 lb. interval. Variability was constant throughout the profile reaching a slightly wider variability at the upper extreme weight group.

The mean squat-jump scores by weight varied little from the 100 to 119 to the 170 to 179 lb. groups. There was a general decrease in scores with increased weight from 180 to 189 to 210 to 219 lb. groups. A decidedly lower mean score was made by the 220 to 239 lb. group. Greater variability was found in squat-jump scores than in any of the other items observed in this study, and variability was generally more regular.

There was a constant regression in mean pull-up scores with increase in weight above the 130 to 139 lb. group. the highest mean score was made by the 130 to 139 lb. weight group and the low mean scores were made by groups 210 to 219 and 220 to 239. There were slight irregularities in variability. Variability was widest at the 200 to 219 lb. interval and smallest at the 100 to 119 lb. group.

It has been customary to regard an r as worthy of confidence if it is at least three times its Standard Error.[3] All the Standard Errors of the data in Table 2 proved to be significant.

In all cases with the exception of Squat-thrusts for Weight, there seems to be significant difference of S.E. of r.

In all cases with the exception of Squat-thrusts for Height and Squat-thrusts for Weight, the r is significant at the 5% level of confidence when the null hypothesis is applied.

Conclusions

1. Profile curves of the regression of test scores against age, height and weight were similar. Each started with a slow increase of mean scores through the first two or three intervals, decreased through the remaining intervals, and finally reached the lowest mean score in all items of the test in the upper intervals according to age, height, and weight.

2. Standard deviations in general remained constant for all test items when age, height and weight were varied.

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[3] Henry E. Garrett, *Statistics in Psychology and Education.* New York: Longmans, Green & Co., 1947. p. 298.

3. There seemed little relationship between age and the scores made on the physical fitness test in the 17 to 30 year age groups. However, consistently lower scores made in all items of the test after 30 years of age may indicate some relationship between test scores and increase in age.

4. Height seemed to affect the mean scores of all items in the test less than age and weight.

5. The test items push-ups, squat-jumps, and pull-ups, demanding strenuous use of leg and arm muscles seemed to be affected by an increase in weight beyond 190 lb. Items sit-ups and squat-thrusts, demanding less strenuous arm and leg muscle-action were affected less by an increase in weight beyond 190 lb.

6. The smallest mean scores made on all items of the test were made by the oldest and heaviest groups.

7. The highest mean scores on the various items were made by the 130- to 139-lb. group, the 70 inch group, and the 21- to 22-year-old group.

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The Influence of Ascorbic Acid in Minimizing Post-Exercise Muscle Soreness in Young Men

Wesley M. Staton

University of Florida
Gainesville, Florida

The incidence of acute localized muscle soreness as an aftermath of unusually strenuous muscular activity continues to pose a major problem in the conduct of training and conditioning programs. The occurrence of this condition in young men is a prominent deterrent to the attainment of optimal physiologic fitness, particularly when a high degree of fitness must be achieved within a relatively short period of time. Such a situation prevails in relation to intramural and varsity athletics in schools and colleges. Under the exigencies of current and protracted international discord, the acceleration of the recruit training programs of the armed forces tends to amplify the problem in the military sense. Moreover, it should be noted that the somatic discomfort of post-exercise muscle soreness is not entirely without an attendant psychic effect which may influence the individual's adjustment and response to the training regimen.

Owing to the scantiness of medical and physiologic data relating specifically to this condition, controlled research concerned with methods of prevention or minimization has been sharply limited. Further explanation of the paucity of experimental investigation of so important a phenomenon may be indicated by the rather elusive characteristics of the condition and the obvious difficulty encountered in the precise appraisement of degrees of muscle soreness.

Review of the Literature

The potentiality for productive research in this area was revealed by the rather intriguing report of Daumezon, Cassan, and Delamarre (6) presented before the Société Medico-Psychologique meeting in Paris in 1945. These investigators claimed markedly favorable results in the prevention of severe muscle soreness by the administration of 300 mg. of ascorbic acid daily. The data indicated that, of the 14 mental patients included in the study, 12 showed complete disappearance of the symptoms of muscle soreness experienced following shock therapy. Although this experiment suffered somewhat from the subjectivity of muscle soreness determination and the failure to offset the psychic factor by including a placebo group, the conclusions prompted Steinhaus (4) to suggest additional study of the problem with particular reference to the type of soreness developing as a sequela to a bout of unusually strenuous exercise.

On the basis of available data there seems to be general agreement that ascorbic acid plays a prominent role in maintaining the cohesiveness of the

cells of the blood vessels and other tissues, as well as contributing to the efficiency of tissue respiration (1, 2, 8, 9, 11, 12, 14, 18). Moreover, the majority of evidence reflects widespread inadequacy of vitamin C in the American diet (3, 5, 13, 15, 16).

Accordingly, it was felt that controlled experimentation along these lines might shed additional light on the problem. The hypothesis was predicated upon the established physiologic values of ascorbic acid saturation. Thus, it was speculatively assumed that the ingestion of liberal amounts of ascorbic acid might be of significant benefit in dissipating accumulated lactic acid, as well as lesser metabolites, and in rendering the muscle fiber more resistant to tearing.

Purpose of the Study

The primary purpose of this investigation is to determine the effect of ascorbic acid saturation on the degree of localized muscle soreness resulting from unusually strenuous muscular activity.

Procedure

The sample included 103 non-pathologic male college students ranging in age from 18 to 22 years. These volunteer subjects were randomly segregated into three separate groups as follows: control, 37; experimental, 33; and placebo, 33. Each subject completed a questionnaire concerned primarily with appraisement of daily diet and general regimen. While none of the subjects appeared to be subsisting on a frankly deficient diet, few indicated that they were ingesting liberal amounts of vitamin C. All subjects were non-athletes, in the varsity sense, and did not participate in any special conditioning program during the 30-day feeding period preceding the testing phase.

Throughout the 30-day preparatory period subjects in the experimental group ingested a 100 mg. ascorbic acid tablet daily. This dosage was based upon the findings of Ralli and her co-workers (17) and Johnson and others (10) indicating that the saturation level in normal adults is established and maintained on a daily intake of from 75 to 100 mg.

Subjects in the placebo group ingested one Abergic Placebo[1] tablet each day during the feeding period. The members of the control group did not alter their usual diet. None of the subjects in the experimental and placebo groups were cognizant of the nature of the dietary supplement.

At the conclusion of the 30-day feeding period, the Havlicek (7) form of the sit-up test was administered to all subjects. The validity of continuous sit-ups as a measure of strength and endurance of the thigh flexor and abdominal muscles has been established (19). Raw scores, indicating the total number of sit-ups performed within a three-minute time limit, were recorded on the occasion of the first testing. Approximately 24 hours later each subject was retested in precisely the same manner. It was hypothesized that the more closely the second raw score approached the first, the less intense was the localized soreness resulting from the unusually strenuous muscular activity of the first day's testing. On the basis of the two raw scores a percentage, or

[1] Abergic Placebo—Upjohn.

index of retest efficiency, was calculated. For example, if a subject performed 50 sit-ups on the first test and completed 40 sit-ups on the retest the following day, he achieved a retest efficiency index, or percentage, of 80.00. This index then, representing the precise degree of retest efficiency, could be considered to reflect, inversely, the gross severity of post-exercise muscle soreness.

Findings

Mean indices for the groups studied were determined from retest efficiency indices of individual subjects within each group. In this manner the significance of the resultant difference between groups could, more properly, be appraised in terms of the reliability of the difference between means rather than on the basis of the reliability of the difference between percentages. Group mean indices, intergroup differences between means, and the reliabilities of these differences are illustrated in Table 1.

TABLE 1

Intergroup Comparisons in Terms of Mean Indices of Retest Efficiency

Group	N	Mean index	s	M_1-M_2	t
Experimental	33	96.52	8.63	2.76	1.10
Placebo	33	93.76	11.55		
Experimental	33	96.52	8.63	5.95	2.07
Control	37	90.57	14.92		
Placebo	33	93.76	11.55	3.19	1.01
Control	37	90.57	14.92		

From the derived critical ratios, it is apparent that the variances holding between the experimental group and the placebo group, and between the control group and the placebo group, are not statistically significant. However, the difference observed between the experimental group and the control group is significant at the .05 level of probability with a critical ratio of 2.07 and 68 degrees of freedom. Accordingly, for these two groups, the null hypothesis is rejected and the variance obtaining between the means is regarded as a significant difference attributable to the influence of the experimental variable, ascorbic acid ingestion.

Although the groups were not equated at the beginning of the investigation, it is noteworthy that there was no significant difference between group mean raw scores for the initial sit-up testing. These raw score means were as follows: experimental, 67.36; placebo, 66.18; control, 66.38.

Summary and Conclusions

It was postulated that the addition of liberal amounts of ascorbic acid to the normal dietary might be of value in minimizing the localized soreness that follows a bout of unusually strenuous exercise. This hypothesis was based upon the established contribution of ascorbic acid to the efficiency of tissue

respiration and to the maintenance of collagenous connective tissue. Throughout a 30-day preparatory period subjects in the experimental group supplemented their usual diet with 100 mg. of ascorbic acid daily. Those in the placebo group ingested one Abergic sham, or placebo, tablet each day while the subjects in the control group did not deviate from their typical dietary pattern.

At the close of the feeding phase of the study, the three-minute sit-up test was administered to all subjects. Approximately 24 hours later the subjects were retested. A percentage, or index, of retest efficiency was determined from the two raw scores attained by each subject. It was assumed that this index reflected, inversely, the extent of post-exercise muscle soreness. Intergroup comparisons were made in terms of group mean indices of retest efficiency and the reliabilities of resultant differences. There was no true difference existing between the experimental group and the placebo group, nor between the control group and the placebo group. However, the difference observed between the experimental group and the control group was significant at the .05 level of confidence.

On the basis of the obtained data, and to the extent that the retest technique validly appraises the severity of muscle soreness, the following conclusions would seem justifiable:

1. The degree of post-exercise muscle soreness is apparently minimized to a significant extent by the addition of 100 mg. of ascorbic acid to the typical daily diet for 30 days prior to strenuous muscular activity.

2. The significant superiority of the experimental group over the control group cannot be accepted without reservation inasmuch as a true difference did not exist between the placebo and experimental groups.

3. Although the variance holding between the placebo and the control groups was not significant, the possibility of influential psychogenic factors must be recognized in the limitations imposed upon retest performance by muscle soreness.

4. Further experimentation, to corroborate or reject the favorable indications of these data, is recommended. In this connection the improved potential of a dietary supplement combining ascorbic acid with hesperidin, or citrin, is suggested.

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The Effect of Weight Training on Speed of Movement[1]

BRUCE M. WILKIN

Oakland Technical High School
Oakland, Calif.

IN THE MINDS of many Physical Education personnel, the idea of "muscle boundness," i.e., the supposed loss of co-ordination and speed of movement due to over-development of musculature, is closely associated with, if not identified with, the weight-lifting or resistance type of exercise. The concept of muscle boundness is poorly defined physiologically, and little information is available from the current writing of a kinesiological nature; physiological studies of muscle itself are similarly of little aid in defining or explaining the "muscle bound" condition.

Efforts by the writer to examine current opinion on the subject have evoked some of the following descriptions of "muscle boundness": (1) Excessive development of protagonistic or antagonistic sets of muscles, resulting in a shortening of the muscles because of higher tonus; (2) excessive size of muscle, limiting mechanically the amplitude of movement; (3) greater "viscosity"; (4) exceptionally high tonus, resulting in jerky, unco-ordinated movements.

Fenn, in a personal communication to Capretta (2) has attributed lack of co-ordination from muscle boundness to the increased amount of developed muscle fibers which must be innervated by the same original amount of neural mechanism. He comments as follows:

"Muscle bound is a term applied to the general condition found in athletes accustomed to heavy muscular work involving the use of large masses of muscle without fine gradations and precise control. Here, I suppose that the muscle fibers are over-developed in relation to the nerve fiber so that one fiber possibly controls a larger number of the fibers. Tendon sense and muscle sense are poorly developed or else the proprioceptive impulses are received 'en bloc' rather than in detail. The subject performs delicate movements awkwardly and without fine adjustment." It is interesting to note that the subject is puzzling to physiologists. Capretta (2) sent a questionnaire to 45 physiologists requesting opinions on the cause of the muscle-bound condition. He received 22 replies: only seven of the men ventured opinions.

He summarizes the results as follows:

"The condition is associated with hypertrophy, and is a condition of overgrowth or excessive development of muscles. It is seen commonly when training is associated with severe muscular strain. The excessive development results in a condition of fibrosis resulting in a preponderance of fibrous linen in muscle bundles due to the amount of stress and strain to which the muscle is subjected."

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[1] From the Research Laboratories of the Department of Physical Education, University of California, Berkeley.

The argument that greater muscular strength provides a greater force, thereby resulting in higher velocities in a given distance, which has been mentioned by Chui (3), deserves consideration. However, he believes that more strength will overcome "muscle viscosity" to a greater extent, thus resulting in more speed. It should suffice to point out that Hill (11) has withdrawn his theory of muscle viscosity which he formulated in 1922. Fenn (5) on the basis of calculation of the work done in sprinting, had already questioned Hill's theory that viscosity is the principal limiter of speed of movement. Even if Hill's "viscosity" theory were applied (as assumed by Chui), "activation" of more muscle fibers hitherto atrophied or unused would result in an increase of sarcoplasm (1), and a parallel increase in viscosity, thus giving no advantage as far as speed is concerned.

In considering force-velocity relationships, Fenn and Marsh (7) have shown that the decrease in muscle tension in sudden movements is approximately 3.1 per cent for a rate of shortening of 10 per cent of the muscle length per second. The muscle is unable to maintain its full force, as developed isometrically, when an isotonic contraction is begun. However, the greater the isometric or pre-release tension, the greater the terminal velocity, as would be expected. Fenn (8) has concluded that the chemical delay in liberation of extra energy for shortening is of chief importance in limiting the speed of contraction of muscle. Henry (10) has found that this "tension loss" factor is most important during the first second or two of a sprint run, with strength being the important determiner of speed of movement thereafter.

Zorbas and Karpovich (20) investigated the speed of movement of a single arm turning a crank in a frontal plane. In a cross-sectional type study, they compared 300 weight lifters and body builders "from various parts of the world" tested at Mr. America contests, body building clubs, etc., with 150 non-weight lifters from Springfield College and 150 "liberal arts college" students. They found that the weight lifting group was significantly faster than the control group, and that the Springfield College subjects were significantly faster than the liberal arts college subjects. The writers of the article, however, have not claimed (except implicitly) that the study shows the effect of weight training. It may be suggested that the interpretation of the study is limited by the fact that the weight lifters were selected from an entirely different population than the control groups.

Statement of Problem

It is proposed to test the hypothesis that training with heavy exercise of the resistance type causes an incipient muscle-bound condition, defined in part as impaired speed of movement. Both cross-sectional and longitudinal experimental designs are to be employed. Specifically, it is proposed to test the speed of movement of the arm action of a group of university students before and after a semester of elementary weight training, and also to test the speed of movement of a group of experienced (chronic) university weight lifters as compared to a control group.

From the review of the literature, it seems that there is some basis for considering an alternative hypothesis which contends that the muscle development due to weight lifting, by increasing strength, results in faster speed of movement.

Methods and Apparatus

Apparatus. The factors to be considered in selecting a test of speed of movement of the whole body are manifold. Therefore, considering the specific problem, a test was devised in which the arms and shoulders, particularly developed in weight work, would be chiefly involved. A device was desired which would require a movement of the arms that would not be practiced directly by the subjects and yet would be simple enough to be operated by all subjects.

The apparatus consisted of a bicycle crank having a radius of $7\frac{1}{4}$ inches, mounted in the frame and attached to a strong upright on the wall, with the axis of the crank 58 inches from the floor. There was no resistance to rotation other than a negligible amount present in the ball-bearings of the crank. Hand grips were made by taping the pedal shaft sleeves. An electrical counter, read at 15-second intervals, permitted analysis of the subject's rate of turning the crank. Both hands were used simultaneously, and the crank was turned at the subject's maximal speed.

Experimental Groups. For the "longitudinal" group (XL), subjects were selected who had had no previous weight lifting experience, so that if there should be an observable effect on speed of movement, it might be attributed to the experimental muscular exercise. These subjects were tested at the beginning and at the end of the semester.

The "cross-sectional" or chronic group (XC) consisted of members of the weight lifting team at the University of California, and some others who had had one year or more of strenuous, continuous weight work. The average length of experience for this group was $2\frac{1}{3}$ years.

Control Group. This group (C) was taken from classes in elementary swimming and golf, since these activities are not considered to be strenuous, as compared with weight lifting, insofar as heavy work done by the arm and shoulder muscles is concerned.

Sizes of Groups; Losses on Retest. Originally, there were 30 Ss (subjects) from the weight lifting class, 28 controls (13 swimmers and 15 golfers), and 15 experienced weight lifters. In the elementary weight class group, 11 dropped the course, and 3 of these had quit on Test I after 30 to 60 seconds. Ten Ss dropped out of the control group. One of these was a swimmer. The other 9 were golfers, thus giving the golf group the highest drop-out ratio. Six of the "chronic" weight lifters of the original 15 failed to take the retest.

The final data, therefore, consisted of tests and retests on 9 chronic weight lifters of group XC, 19 beginning weight lifters who composed group XL, and 18 beginning swimmers and golfers who composed group C, the controls.

Procedure. Ss were not told beforehand that there was to be a test and retest, in order to avoid any chance of deliberate "loading" or avoidance of maximum effort on the first trial. Appointments for the second trial were made after the entire group had finished the first trial. All Ss were volunteers; it was hoped that this would help to increase and standardize motivation. In administering the test, subjects were brought to the test room in groups of two or three with the idea of motivation in mind. Each S was given a 10-second trial to familiarize himself with the apparatus, and then instructed to put forth a maximum effort in turning when given the starting signal.

The test and retest were two months apart. The average net time spent in weight lifting for group XL was one hour and fifteen minutes per week, estimating one-half hour of work for each period, plus extra work-outs. The XC or "chronic" group averaged at least one hour per day of work with the weights.

Experimental Results and Discussion

Individual Differences. While the primary interest of the study was not in individual differences but rather in group differences, reliabilities of the test were calculated for the periods 0 to 15 seconds and 60 to 75 seconds, as well as the drop-off in rate between the first and last periods. These correlations were quite variable, probably because the number of cases was small. They ranged from .67 to .95 for the period 0 to 15 seconds, and from .61 to .96 for the drop-off. For the period 60 to 75 seconds the correlations were lower, ranging from .13 to .75. These results are shown in Table 1; also given therein are the means and standard deviations.

The test-retest correlation for the 60–75 second period for the controls was .75, which is significantly greater than zero. For the 28 Ss of the combined experimental groups it was .161, which is not statistically significant. The t ratio for the difference in these two correlations is 2.8, which is statistically significant. Apparently weight training, for some reason, disrupts the individual differences in the "fatigued" part of the speed of movement test, although they are present in the C group that participated in swimming and golf. An explanation of this finding is that weight training improves endurance by varying amounts in different individuals, thus reducing the test-retest correlation for these groups. The observed correlations agree with this explanation. It will be shown below that there is some indication in the data that weight training does improve endurance. The C group shows no such improvement. Its "fatigued" speed shows a relatively high test-retest correlation, $r = .751$. The XL weight lifters tend to show a slight increase in endurance and their test-retest "fatigued" correlation is only $r = .174$. The XC or chronic weight lifters who had the most weight training during the semester show the strongest indication of improved muscle endurance and the smallest test-retest "fatigued" correlation, $r = .134$.

Differences in Groups. The groups were not made up by random sampling, this being impossible because of the various criteria for the different groups. In the control group, the beginning swimmers averaged 6 per cent faster than

the beginning golfers in the first period of Test I. This is not a statistically significant difference ($t = 1.0$).

The elementary weight lifters (XL) averaged 9 per cent slower than the controls in this first period, which is a significant difference at the 2 per cent level of confidence ($t = 2.4$). This slower group might have been in poorer physical condition, since many expressed the wish to "get in shape" by taking the weight course. This apparently selective factor involved in the weight training group might be anticipated from the results of Thune's study (18) and it could possibly be the main reason for the initial difference between the two groups.

The chronic (XC) group, on the other hand, did not differ significantly from the control group ($t = 1.2$). This group, it should be remembered, had an average history of over two years of intensive weight training.

Equated Groups. As a matter of interest, the C group and XL groups were equated by removing four of the faster cases from the C group and four of the slower cases from the XL group. It was found that the groups did not then differ significantly in any period of the test or retest. Let it here be said that the writer realizes the invalidity of such a statistical procedure, which in effect narrows the sample variability without changing the parameter or distribution from which the sample is drawn.

TABLE 1

Means and Test-Retests Correlations

Group	15-second period			75-second period			15 second minus 75 second		
	Mean	σ	r	Mean	σ	r	Mean	σ	r
C[8] I	53.3	5.19		37.7	2.83		15.6	5.83	
C II	56.4	5.76	.669	38.8	3.78	.751	17.6	5.65	.658
XL I	48.7	6.18		36.8	3.26		11.9	4.74	
XL II	51.0	5.60	.737	36.8	2.94	.174	14.2	5.86	.610
XC I	50.0	7.18		36.4	2.27		13.6	6.89	
XC II	56.6	4.40	.951	39.5	1.74	.134	17.1	4.72	.957
All Groups									
I	50.8	6.39		37.3	2.97		13.5	5.83	
II	54.0	6.12	.748	38.9	3.31	.424	15.1	5.77	.704

Changes in Speed of Movement. It was found that all three groups showed a significant increase in Test II compared with Test I, in the first 15-second period (Tables 2 and 3). For the control group, this may be considered a practice effect, and for the other two groups, as practice effect plus any effects due to the weight training program.

Further inspection of these tables shows that while the C group shows significant change only in the 0–15″ (first) period, the XL group improved in the first three periods (i.e., up to 45″) and the XC group improved in all five periods (i.e., during the entire 75″ test). This tendency to maintain the more rapid pace of the initial period of retest is therefore greatest in the Ss who did the most weight training between test and retest and seems to represent an improvement in endurance or increased toleration of fatigue. The

TABLE 2
Mean Scores of Groups (By Periods)

Group	Trial	Period 15 sec.	30	45	60	75	Mean increase
C	I	53.3	46.8	42.3	38.9	37.7	
	II	56.4	48.6	43.0	40.9	38.8	
Increase in Rev.		3.1	1.8	0.7	2.0	1.1	8.7
XL	I	48.7	42.4	39.8	38.1	36.8	
	II	51.0	45.8	41.7	38.6	36.8	
Increase in Rev.		2.3	3.4	1.9	0.5	0.0	8.1
XC	I	50.0	45.2	40.3	37.2	36.5	
	II	55.6	48.2	43.7	40.7	39.4	
Increase in Rev.		5.6	3.0	3.4	3.5	2.9	18.4

TABLE 3
Critical Ratio (t) of Differences Between Test and Retest

Group	Period 15	30	45	60	75	"t" required at: .05 level	.01 level
C	2.96	1.20	.95	.34	.18	2.11	2.90
XL	2.27	3.80	3.19	.48	.05	2.10	2.88
XC	4.70	2.86	3.21	3.22	3.04	2.31	3.36

evidence is in the opposite direction to any indication in incipient muscle boundness.

This is only a tendency, not a proven fact, since a comparison of the *improvements* (Table 4) shows no statistically dependable difference in favor of the experimental groups except for the borderline t at the 45-sec. period for the XC group. However, the differences for the XC group are consistently positive.

TABLE 4
Comparison of Increases Between Control and Experimental Groups

Group	Period 15	30	45	60	75	"t" required at: .05 level	.01 level
XL − C diff.	−0.8	1.6	1.2	−1.5	−1.1	2.03	2.72
t	−0.51	1.59	1.20	−1.37	−0.89		
XC − C diff.	2.5	1.2	2.7	1.5	1.8	2.06	2.79
t	1.59	1.20	2.03	1.13	1.61		

Evaluation of Results. The most crucial aspect, in proving or disproving the hypothesis that weight training has a slowing effect on speed of movement, was the comparison of increases (between test and retest) of both experimental groups with the increase in the control group. As shown in Table 4, the XL group showed no consistent or significant difference from the

controls, and the XC or chronic weight lifters showed a consistent, although statistically insignificant, *improvement* compared with the controls. Therefor the hypothesis that training with weights improves speed of movement remains unproved statistically, but the trend of the data favors this idea.

Comparison With Other Studies. The finding of Zorbas and Karpovich that weight lifters have a slightly faster speed of movement than controls is in the same direction as the effect of chronic weight training as observed in the present study. While no significant difference is found in initial speed before training, it can be calculated that a difference as small as that observed by them would probably not show up as significant in groups as small as those used in the present study. Apparently no other studies of this type have been reported in the literature.

Strength and Speed. A correlation between the speeds of the XL group in the first 15-second period and an average of the maximum weight lifted in three lifts resulted in an r of $-.268$. The correlation is insignificant. One would expect a much higher correlation than this if the strength factor were all-important in this situation. Strength may create speed, but strength gained from weight lifting does not greatly help to turn a crank faster, or if it does, the effect is balanced out by an equal decrease in speed from muscle-boundness. The sign of the correlation is also in the wrong direction.

Considering all the foregoing evidence, there is no good basis to argue that greater strength gives greater speed in the arm movement test, though there is probably some point below which a lack of strength would definitely limit speed of movement.

In the Zorbas and Karpovich study, the average speed for the first 5.6 seconds of turning was 4.3 revolutions per second, with a standard error of .012. In the present study, by drawing a smooth curve through the average rates for the 15 second periods, it can be estimated that the speed for the first 5 seconds was 3.53 revolutions per second, with a standard error of .064. This slower speed can be accounted for by the difference in type of movement used in the two experiments. In both cases the speed is much slower than the average of 6.3 revolutions per second for the legs when turning an unloaded bicycle as reported by Slater-Hammel (16).

Fatigue Curves. As a matter of interest, the data for all subjects were averaged and examined to see if the fatigue curve obtained by plotting the rates of movement in the successive time periods was of some simple mathematical form.[2] Henry (10) has stated that many types of performance and biological functions follow an exponential curve. Under the assumption that the rate of turning decreases from the initial maximum and approaches a steady-state value, the excess of movement over and above this steady-state speed is found to obey an exponential law as shown in Figure I, and the resulting mathematical equation predicts the observed rates quite well, as shown in Figure II. According to the exponential law, a constant proportion of the speed at any particular time, over and above the hypothetical steady-state, is lost in the next time period. In this particular case, it can be seen in the

[2] The writer is indebted to Dr. Franklin M. Henry for help in this mathematical analysis, and for advice concerning other phases of the study.

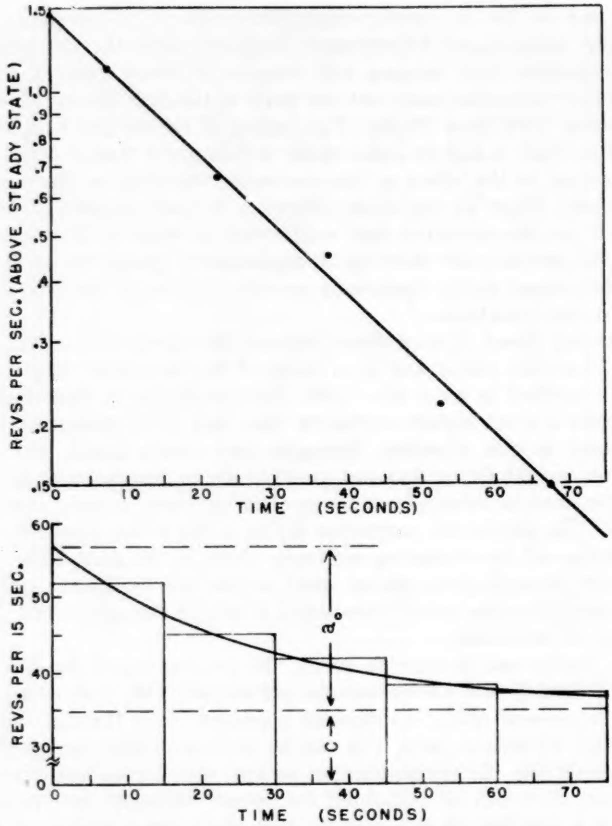

Fig. I. (*Upper*). Observed rates of turning and semi-log graph of the formula $y = a_o e^{-kt}$.

Fig. II. (*Lower*). Observed rates of turning per 15-second interval and theoretical curve computed from the formula $y = a_o e^{-kt} + C$ (where $a_o = 21.9$, $k, = .0345$, and $C = 34.8$.

graphs that half of the existing extra speed at a particular moment is lost every 20 seconds, or 40 per cent is lost in each 15-second period.

Conclusions

1. Weight training, over a period of one semester, has no slowing effect on speed of arm movement as measured in this study.

2. The chronic weight lifter is not "muscle-bound" in the sense that his speed of movement is impaired. His speed is as great as that of other students studied, and improves as much or more during a semester of training.

3. A semester program of weight training does not increase speed of movement more than a semester of beginning swimming or golfing.

4. The results suggest that daily training with weights may improve muscular endurance.

5. Individual differences in maximum speed of arm movement are definitely present, since the test-retest correlation for the total group of 46 cases was .75. This correlation does not differ significantly between weight lifters and swimmers and golfers.

6. Weight training for a semester disrupts individual differences in speed during the *fatigued* part of the arm movement test, since the test-retest correlation was only $r = .16$ compared with $r = .75$ for students who participated in a semester of swimming or golf. The apparent explanation is that weight training improves muscle endurance, but affects some individuals more than others, which causes the test-retest correlation to disappear in the "fatigued" part of the speed of movement curve.

7. The fatigue effect, or slowing of the rate of movement during the test, follows the exponential formula $y = a_o e^{-kt}$ with a half-time velocity coefficient of 20 seconds.

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Continued from the May Quarterly

Research Abstracts

Prepared by the Research Abstracts Committee of the National Council of the Research Section, *Carolyn W. Bookwalter, Chairman*

Anatomy and Physiology

43. DEFOREST, RALPH E. Present status of use of ultrasonic energy in physical medicine. *J. A. M. A.*, **148:** 646 (Feb. 23, 1952).

The effect of maximal doses of ultrasonic radiation was investigated on anesthetized dogs. These doses may cause severe pathological damage to the spinal cord, peripheral nerves, growing bones, joints, and testes. The amount of tissue destruction varied with the type and density of the tissue exposed to radiation and the length of exposure.

Presently, the only known therapeutic value of ultrasonic radiation is that of a selective heating agent.—*John L. Neumann.*

44. DEXTER, J. L., J. L. WHITTENBERGER, F. W. HAYNES, W. T. GOODALE, R. GORLIN, AND C. G. SAWYER. Effect of exercise on circulatory dynamics of normal individuals. *J. of Applied Physiology*, **3:** 439–453 (Feb. 1951).

Seven normal subjects were tested for cardiac output, pulmonary and capillary pressure, and pressure flow relationships in both ventricles at rest, during, and after 3-minute mild recumbent exercise bouts. Exercise resulted in increased cardiac output and arterio-venous oxygen difference with rise of pulmonary arterial pressure, negligible rise of pulmonary "capillary" pressure and no significant change in pulmonary arteriolar resistance when oxygen consumption exceeded 400 cc./min./m^2. With 500 cc. oxygen consumption right ventricle work increased threefold and left ventricle twofold.—*W. D. Baillie and Dorothy Ring.*

45. GARN, STANLEY MARION. Physical growth and development. *Am. J. Phys. Anthrop.*, **10:** 2 (June 1952).

This review deals with those approaches and problems in growth and development of interest to physical anthropologists. Beginning with a brief definition of the processes of growth and development, it considers material suitable for investigation, including prenatal, neonatal, and postnatal data, as well as inferences that can be drawn from pathological and abnormal states. Using the so-called problem approach, the relevance of growth studies to physical anthropology is considered. Then, the kinds of problems relevant to different periods of growth are discussed; developmental defects, prematurity, neonatal changes, sex, and race differences, socio-economic differences, and secular changes are reviewed. Furthermore, growth changes are considered well beyond the legal age of majority.

In a concluding section, the problem of appraising individual growth is posed, commonly used methods of appraisal are mentioned, and the conclusion is drawn that, despite grids, graphs, and norms, and despite the vast amount of metrical data that has been accumulated, the appraisal of individual growth is still highly subjective. More attention to individual growth records is to be desired.—*The Wistar Institute.*

46. GOLDWATER, L. J., L. H. BRONSTEIN, AND BEATRICE KRESKY. Study of one hundred seventy-five "cardiacs" without heart disease. *J.A.M.A.*, **148:** 89–92. (Jan. 12, 1952).

Seven hundred six persons with supposed heart disease were restudied. It was found that 175 (about 28%) of them were given erroneous diagnoses because of faulty interpretation of benign systolic murmurs, tachycardia and palpitation. Nearly half had been given a diagnosis of heart disease on a routine examination by physicians in the armed forces, in schools, and in industry.

The majority of these 175 so-called "cardiac" patients were males of under 35 years of age, who might have been gainfully employed. Twenty-five per cent were not working because of alleged heart disease. Irreparable psychic traumata were often produced when patients with supposed heart disease were advised to limit their activities.—*Eng-Hauw Tan and Peter V. Karpovich.*

47. HERTZBERG, HANS THEODORE EDWARD AND GILBERT SAMUEL DANIELS. Air Force anthropology in 1950. *Am. J. Phys. Anthrop.*, **10:** 2 (June 1952).

This paper lists some of the occupations of the Anthropology Unit, Aero Medical Laboratory, Wright-Patterson Air Force Base in 1950. The chief effort was the accomplishment of a new body survey in which 132 measurements were taken on about 4050 Air Force flying personnel, as well as somatotype photographs and some sociological data. "Production line" methods of measurements are briefly described, and some new measurements are mentioned. The study of human muscle strength and efficiency is mentioned with a short summary of the results. The example chosen is the foot-pedal angle-and-torque study. Comfort studies are exemplified by the prone position bed for pilots and the stick grip development for fighter airplanes. New types of body information needed by the Air Force are outlined, such as data on human center of gravity, location of hinges with respect to body surface, body volumes, and the like. This paper calls for academic recognition of applied physical anthropology as an important and growing speciality within the general professional field.—*The Wistar Institute.*

48. KJELLBERG, S., ULF RUDHE AND TORGNY SJOSTRAND. The Effect of Adrenaline on the Contraction of the Human Heart under Normal Circulatory Conditions. *Acta Physiologica Scandinavia*: **24:** 333–349 (Feb. 12, 1952).

The effect of the infusion of small doses of adrenaline in man with intact circulation was studied. The analyses were made with electrokymography, phonocardiography and electrocardiography. Nine male medical students and three nurses, all between 20 and 26 years of age were the subjects.

It was found that adrenaline (1) shortens the isometric contraction phase, (2) accelerates the speed of contraction, (3) increases the systolic emptying of the left ventricle, (4) increases the amplitude of the first and second heart sounds, (5) lowers the diastolic pressure, (6) increases the amplitude of the pulse pressure and (7) usually increases the heart rate. In addition, adrenaline alters the T-wave of the E.C.G.

The increase in the stroke volume of the left ventricle is not associated with any increase in the volume of the heart during diastole. This implies a more complete emptying of the ventricle, i.e. a decrease in its residual blood volume.—*Paul Hunsicker.*

49. MEDELMAN, J. P., AND JOHN F. BRIGGS. Routine chest examinations in a private hospital. *Minnesota Medicine*, April 1952, p. 340.

After a year of operation the authors assess results of a program of taking four by five inch chest photofluorograms of as many patients as possible on admittance. A check for one month shows during that period, after the program had been under way about a half year, 92 per cent of the patients admitted either had photofluorograms or standard roentgen chest examinations. The authors regard the miniature film as a screening device rather than an instrumentality for final diagnosis. For staff checkups and routine admittance screening, they feel that the smaller film is adequate and has the advantage of economy and convenience. They discuss technics and procedure, and append a table of 848 lesions found out of 6,292 patients who had routine admittance films (plus an unstated number for whom regular chest x-rays were ordered.)—*Medical Abstract Service.*

50. OSBORNE, S. L. The retardation of atrophy in man by electric stimulation of muscles. *Arch. Physic. Med.*, 32(8): 523–528 (1951).

Six patients with denervated muscles of arms were treated 5 min. daily for 5 to 18.5 mo. Muscle volume (by water plethysmograph) and girth were measured. Muscular atrophy was retarded, but atrophy which occurred before treatment was irreversible.—*P. V. Karpovich.*

51. Roche, Pat, Richard A. Dodelin, and Walter L. Bloom. Effect of dextran on blood typing and crossmatching. *Blood*, March 1952, p. 373.

The 26 patients studied had normal and abnormal circulatory dynamics. The dextran was hydrolized and fractionized so that most of the molecular sizes were distributed in the physiologic range of plasma proteins, particularly albumin. A 6 per cent solution in saline was used in 23 patients and a 12 per cent salt-free dextran in the other three. Blood determinations were done in the usual manner and dextran levels were done by the method of Bloom and Wilcox. The authors conclude that partially hydrolized dextran used for the expansion of plasma volume has been shown to have no effect on typing, crossmatching, or Rh determination of blood from normal patients or patients in shock. It is not necessary, therefore, to take blood for these determinations before administering the substance, even though this has been necessary in the past when macrololecular preparations were used.—*Medical Abstract Service.*

52. Von Gierke, Henning Edgar, Horace Olin Parrack, and Donald Herbert Eldridge. Heating of animals by absorbed sound energy. *J. Cell. and Comp. Physiol.*, **39:** 3 (June 1952).

In order to explain the observed heating and killing of small animals in sound fields above about 150 db ref .0002 dyne/cm^2, the sound absorption coefficient of rat's body surface is measured as a function of frequency. The absorption coefficient decreases up to about 1500 cps and then increases up to 6,000 cps. The behavior below 1,500 cps is determined largely by the tissue beneath the skin while the increased absorption above 1,500 cps is the result of the presence of fur. These absorption coefficients permit the estimation of the sound energy absorbed by a whole animal. By calculating the heat balance of the animal in a sound field, the sound intensity and the time required to cause heat death can be calculated approximately. These calculated results agree with the new experimental data on the heat death of rats and establish overheating as the agent responsible for death.—*The Wistar Institute.*

53. Chapters and the Economic Status of the Profession. *Bulletin of the American Association of University Professors*, **37:** 2 (Summer 1951).

A questionnaire was sent to the Chapters of the American Association of University Professors. This questionnaire requested information concerning increases in faculty salaries received since 1945 to offset the rise in living costs. Returns were received from 106 Chapters. Of the 106 returns, 104 could be used, at least in part. These 104 were rather evenly divided between publicly supported and privately supported institutions.

The conclusions of the study were as follows: (1) the cost of living has risen sharply, and academic salaries have not kept up with it, making the economic status of the faculty, which was not too good before the war, much worse; (2) whereas the real income of college teachers has fallen, the real income of most other professions has risen, making the colleges unable to meet the competition of other callings in inducing persons of first-class ability to enter or stay in the teaching staff; (3) salaries at the home institution are not adequate to compete with other institutions in the region or group—institutions that "we" fondly but often mistakenly hope that "we" are actually competing with; (4) an unfavorable salary situation is inimical to the efficiency and morale of the members of the faculty, and if not remedied, bodes ill for the future of the institution as well as for the future of higher education in general in the United States.—*Jackson M. Anderson.*

54. Eilenberg, Jeanette H. A survey of attendance regulations in American colleges. *School and Society*, **75** (1953): 329–332 (May 24, 1952).

This study was based on 226 replies from a questionnaire sent to 268 representative colleges and universities in all states. It was found that 92 per cent of the institutions had attendance regulations. Approximately 70 per cent of these institutions made attendance taking in each class mandatory and instructors had to report absences at regular intervals. Twenty per cent of the schools left such reporting to the instructor's discretion. Special conditions governed the remaining schools. Unlimited absences are permitted in 15 per cent of the colleges. For the rest of the institutions, regulations limit absences. Approximately 90

per cent of the institutions have one set of regulations for all types of classes. Regulations in many institutions differ for upper and lower classes as well as for the scholastically superior student.—*D. B. Van Dalen.*

55. HEGSTED, DAVID MARK, IRMA MOSCOSO, AND CARLOS COLLAZOS CHIRIBOGA. A study of the minimum calcium requirements of adult men. *J. Nutrition,* **46:** 2 (Feb. 1952).

Calcium balances were determined in ten apparently healthy adult men who had consumed diets fairly low in calcium over an extended period of time. The estimated mean requirement to maintain calcium balance was between 100 and 200 mg per day, depending upon the method of calculation. Some evidence is presented that the minimum requirement is a function of body calcium reserves. It is suggested that estimates of calcium requirements for maintenance represent primarily an estimate of the previous calcium intake. Hence estimates of the minimum requirements can be obtained only with subjects who have consumed relatively low calcium diets over long periods of time. Since a review of the literature reveals no solid evidence of calcium deficiency in adult males, the minimum requirement appears to be so low that that deficiency is unlikely on most diets. When calcium supplies are limited, little effort should be made to increase calcium consumption by adult men. Available calcium should be reserved for children and pregnant and lactating women. It is emphasized that dietary recommendations should be realistic in relation to available food supplies.—*The Wistar Institute.*

56. HOAGLAND, RALPH, GEORGE SNIDER, AND CLIFTON EUGENE SWIFT. Nutritive value of lard as affected by the proportion of fat in the diet. *J. Nutrition,* **47:** 3 (July 1952).

Modified paired feeding experiments were conducted with three groups of eight young male albino rats to determine the effects of feeding for eight weeks isocaloric diets containing 5.0, 10.98, and 18.27% of lard upon gains in weight, fat, protein, and energy and upon the efficiency of utilization of feed energy. No statistically significant differences were found in the gains in weight, in the storage of fat, protein, or energy or in the efficiency of the utilization of feed energy as related to the fat content of the diets.—*The Wistar Institute.*

57. JOHNSTON, FRANCES ANN, AND THELMA JOSEPHINE MCMILLAN, with the technical assistance of GLADYS DERBY FALCONER. The amount of nitrogen retained by 6 young women on an intake of approximately 70 gm of protein a day. *J. Nutrition,* **47:** 3 (July 1952).

Six young women 20 through 31 years of age were maintained for 12 weeks on a diet which was constant except for the addition of a 120-gm serving of spinach a day during the last eight weeks. Weekly composites of urine, feces and duplicates of the diet and composites for each menstrual period were analyzed for nitrogen. The mean intake of protein on the basal diet was 67.0 gm, which was raised to 71.8 gm after the addition of spinach. The mean amount of nitrogen retained during the entire 12 weeks of the study was 0.64 gm per day, or 0.61 gm after the loss of nitrogen in the menses was deducted. The amount varied widely from week to week for a given subject but the means for the 12 weeks were similar for all six subjects. The subjects retained this amount despite the omission of all animal protein from the breakfast. Approximately 91.1% (S.E., 4.6%) of the nitrogen of the spinach was absorbed.—*The Wistar Institute.*

58. LAND, CALVIN ALLEN, ROBERT ADOLPH HARTE, CARROLL LOCKARD CONLEY, AND BACON FIELD CHOW. Retention of crystalline vitamin B_{12} by healthy male individuals following intramuscular injection. *J. Nutrition,* **46:** 2 (Feb. 1952).

The urinary excretion of vitamin B_{12} as measured microbiologically is in the order of 150 μg per 24 hours in healthy males enjoying good dietaries. When such individuals are given, by intramuscular injection, doses of vitamin B_{12} ranging from 20 to 75 μg, the retention of the vitamin as measured by the difference between the injected dose and the urinary output is related to the dose. At levels of 20 and 30 μg virtually all of the administered vitamin is retained. At levels of 50 and 75 μg approximately 80 and 70 per cent respectively, is retained. Substantially all of the excess vitamin injected is excreted in the urine within the first eight hours following injection.—*The Wistar Institute.*

59. Mertz, Edwin Theodore, Elizabeth Jane Baxter, Lois Emma Jackson, Charlotte Elizabeth Roderuck, and Adelia Emily Weis. Essential amino acids in self-selected diets of older women. *J. Nutrition,* **46:** 3 (March 1952).

In a co-operating study of the nutritional status and dietary habits of older women, the daily intakes of seven essential amino acids have been determined by analysis of food composites collected during nitrogen balance studies on self-selected diets. Food composites stored in acid, and representing the self-chosen diets of eighteen older women living in either Michigan, Iowa, or Missouri, were analyzed microbiologically for isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and valine. The levels of intake of isoleucine, leucine, lysine, threonine, and valine usually equaled or exceeded the levels recommended by Rose for human young adult males, whereas phenylalanine was intermediate and methionine intake rarely reached the recommended levels and in many cases was below the minimum level. Methionine appears to be the first limiting essential amino acid in the self-selected diets studied.—*The Wistar Institute.*

Psychology

60. Lamke, T. A. Personality and teaching success. *J. Experimental Education,* **20:** 217 (Dec. 1951).

The investigation attempts to answer two questions:

1. Are the personalities of good and poor teachers, as evaluated by Cattell's 16 Personality Factor Test, characteristically different?

2. Are the personalities of good and poor teachers, as evaluated by a paired comparison scale based on Cattell's 20 surface traits, characteristically different?

Subjects are 32 University of Wisconsin graduates in their first teaching position in the Wisconsin public schools.

Criteria of success are teaching effectiveness as judged by expert opinion and acceptability of the teacher to his principal or superintendent.

Data were analysed by Fisher's discriminant function and by the factor analysis technique.

Findings indicate that a high relationship exists between the criteria of teaching success, and that teaching acceptability and efficiency are probably not distinctive measures of success.

Furthermore, there do not appear to be well defined or characteristic personality patterns for either good or poor teachers. Several patterns exist for good teachers and several patterns for poor teachers.—*Marjorie Phillips.*

61. Neu, D. M. The effect of attention-gaining devices on film-mediated learning. *J. Educational Psychology,* **42:** 479 (Dec. 1951).

The purpose of the study was to determine the relative effectiveness of attention-gaining devices in increasing learning from a motion picture.

Five versions of a film presenting an introduction to machine shop measuring instruments were developed in which: (1) No attention directing devices were used, (2) Visual attention gaining devices related to the points of content being emphasized were used, (3) Visual attention gaining devices unrelated to the points of content being emphasized were used, (4) Sound track attention gaining devices related to points of contact being emphasized were used, (5) Sound track attention gaining devices unrelated to points of contact being emphasized were used.

The subjects were 1576 Army and 1055 Navy recruits. Six randomized groups were used, five of the groups were each shown one of the film versions and immediately afterwards given information and recall tests. The sixth group was given the tests but saw no films.

Analysis of results showed that substantial learning took place in all groups that viewed the film as compared to the group not viewing the film.

There is no evidence to indicate that relevant attention gaining devices promote learning. There is some evidence indicating that irrelevant sound devices retard learning.

There appears to be no difference in the effectiveness of visual and sound attention gaining devices.—*Marjorie Phillips.*

Guide to Authors

In line with the over-all goal of making Association publications yield the greatest value to the individual and the profession, the following is a guide for the preparation of research manuscripts. The information below recognizes general techniques being employed by research publications similar to the *Research Quarterly*. When copy is prepared in accordance with these instructions, all Association research studies will follow a standard style.

Manuscripts

Manuscripts should be sent to the Editor (AAHPER, 1201 Sixteenth Street, Northwest, Washington 6, D. C.), who will see that each one is read by at least three members of the *Research Quarterly* Board of Associate Editors. On the basis of the three reviews, the Editor will advise the author as to the suitability of the paper or the desirability for revision. Papers are not judged by arbitrary standards but on their content of new research results in the field of physical education, health education, and recreation, presented with the greatest brevity compatible with scientific accuracy and clarity.

Since three members of the Board of Associate Editors review an article, it is requested that three clear copies of the manuscript be submitted in order to facilitate reviewing. A fourth copy of the article should be retained by the author. Only one copy of any charts, photographs, drawings, graphs, or similar illustrative material need be submitted. However, since such material must be sent to each reviewer in turn, more time must be allowed for the reviews.

Typewritten manuscript should be double-spaced on white paper of ordinary weight and standard size (8½ x 11 inches).

The sheets of manuscript should be kept flat and fastened with clips which can be removed easily. The pages of the typewritten copy should be numbered consecutively in the upper right-hand corner.

Paragraphs should be numbered consecutively throughout the manuscript, to facilitate ease of reference in case of revision.

Headings

The article should be arranged so as to indicate relative values of heading and subheadings.

Usually four gradations are sufficient: (a) article title, (b) first subhead appearing in boldface aligned left on page (underscored in manuscript with wavy line), (c) second subhead (if necessary) appearing in small caps aligned left on page, (d) third subhead, to appear in italic (underscored in manuscript), not centered, but run in at the beginning of the paragraph or section.

All headings should be typed in lower case with initial capitals, except for (c) above, which should be typed in capital letters.

Documentation

FOOTNOTES

Footnotes are not to be used for references or literature citations. They are rather used for the purpose of acknowledgment, special explanation, supplementary information, etc. (*See examples below.*)

Type footnotes (if any) on separate sheets, as many footnotes as convenient being written on a sheet. Footnotes should be numbered from 1 up for each article; a corresponding numeral appearing in the text. Asterisks should not be used.

Examples of Footnotes:

[1] This study was made under the direction of Dr. Arthur T. Slater-Hammel in the Research Laboratories, School of Health, Physical Education, and Recreation, Indiana University, Bloomington, Indiana.

[2] All measurements of the hand were recorded in centimeters and height was recorded in inches. The hand measurements were taken by Everett and reliability coefficients of above .90 were found for each measurement used in the study.

[3] For their wholehearted co-operation in facilitating collection of the data, special gratitude is extended to Superintendent Clarence Hines and the 1950–51 principals of the Adams, Condon, Edison, Francis Willare, Harris, Howard, Lincoln, River Road, and Whiteaker schools.

CITATIONS OF LITERATURE

Citations of literature should be segregated alphabetically by author's last name at the end of each article, under the caption of "REFERENCES." *Do not treat them as footnotes.* (*See above.*)

The literature citations, listed alphabetically, should be numbered consecutively, their location in the text being indicated by corresponding numbers written in full size and enclosed in parentheses: for example, (1) (2, 3). If there are several references in the text to a citation, the specific pages may be indicated thus: (1, *p. 117*) (1, *pp. 162–3*).

A uniform style should be maintained in writing citations. Do not enclose titles of chapters and articles in quotation marks. Italicize (underscore in manuscript) names of books and periodicals, bulletins, etc. (*See examples below.*)

Uniform sequence of data should be observed, as follows: *For a book*—Author's name (last name first); title of article or chapter; name of book; place of publication; publisher; year date; number of pages or specific pages referred to. *For a periodical*—Author's name (last name first); title of article or chapter; name of periodical; volume number; page numbers; year date; specific pages (if any).

Examples of References Appearing at End of Article:

1. American Association for Health, Physical Education, and Recreation, Health Education Division, Suggested Platforms for Health Education, *Journal of the American Association for Health-Physical Education-Recreation*, **18:** 436 (Sept. 1947).

2. American Association of School Administrators. *Health in Schools*. Revised edition. Washington, D. C.: the Association, a department of the National Education Association, 1951. pp. 266–7.
3. DEAVER, G. G., Exercise and Heart Disease. *Research Quarterly*, **26**: 24–34, 1939. p. 26.
4. OGDEN, JEAN, AND JESS OGDEN. *Small Communities in Action*. New York: Harper & Brothers, 1946. 244 pp.
5. POTTER, JOHN NICHOLAS. *Physical Fitness of Junior High School Boys*. Unpublished Master's thesis, University of California, Berkeley, 1942. 39 pp., p. 15.

Tables

Each table should have a descriptive heading and should be specifically referred to in the text by number, *e.g.*, "Table 10," etc., never as "the above table" or "the following table." Number tables from 1 up for the entire manuscript, using Arabic numerals.

Tables should be double-spaced typewritten, like the rest of the material in the manuscript. They should be typed on separate sheets, as the printer will set them on a different machine from the one used for the text matter. If a table continues on a second sheet, it is not necessary to repeat the boxheads, the printer repeating when necessary from the original boxheads.

The word "TABLE" should be written in capital letters, as: "TABLE 1"; the table title should be written in lower case letters with initial capitals, and centered over the table. Tables should be ruled as desired, except that no rules will appear at the extreme right and left edges of the table. No double rules are to be used, unless necessary for clarity.

Illustrations

Illustrative material is of two types: pen and ink drawings, which are reproduced by the line engraving process; and photographs, wash drawings, stipple drawings (in short anything containing shading), which are reproduced by the halftone process.

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The Association will assume complete engraving expense.

Special Points of Style

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Use Arabic figures for all definite weights, measurements, percentages, and degrees of temperature (for example: 2 kgm., 1 inch, 20.5 cc., 300°C.). Spell out all indefinite and approximate periods of time (for example: over one hundred years ago, about two-and-one-half hours). For numerals used in a general sense, spell out numbers through ten and use Arabic figures for 11 and over (seven times, five years old, 11 students).

ABBREVIATIONS

The metric system being in universal usage, standard abbreviations should be used whenever the weights and measurements are used with figures, i.e., 10 kgm., 6.25 cc., etc. The forms to be used are: cc., kgm., mgm., mm., l., and m. *Gram* should be spelled out in all cases to avoid possible confusion with *grain*. All obscure and ambiguous abbreviations should be avoided. Spell out English weights and measures (for example: ounce, pound, inch, foot, yard, mile). Preserve uniformity in all abbreviations.

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3. * **Physical Education in Small Schools.** 1948. 158 pp. $1.00
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5. **Physical Education for Children of Elementary School Age.** Recommendations of a representative National Conference on Elementary School Children. 1951. 47 pp. 50c
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